Table of Contents

Chapter 6 - Flow Control Facility Design

6.1 Introduction

This chapter of the stormwater manual focuses on techniques and BMPs related to implementation of Core Element #6 – Flow Control. This chapter presents methods, criteria, and details for hydraulic analysis and design of flow control facilities. Flow control facilities are detention, infiltration, or evaporation facilities engineered to meet the flow control standards specified by the regulatory agency.

The design criteria outlined in this chapter are applicable only to those infiltration facilities used for runoff quantity control. Design criteria for infiltration facilities used for runoff quality treatment are listed in Chapter 5.

Design considerations for conveyance systems are not included in the stormwater manual, as this topic is adequately covered in standard engineering references.

In the general design of flow control facilities, the optimal placement of multiple small-scale retention/infiltration facilities within a drainage area may require less total storage capacity to meet a given peak flow rate target than a single large facility at the drainage outlet. Application of low impact development (LID) techniques may also result in decreased storage requirements; see the discussion in Chapter 2.2.6, Supplemental Guidelines.

6.2 Detention Facilities

This section presents the methods, criteria, and details for design and analysis of detention facilities. These facilities provide for the temporary storage of increased surface water runoff resulting from development pursuant to the performance standards set forth by the regulatory agency.

There are three primary types of detention facilities described in this section: detention ponds, tanks, and vaults.

6.2.1 Detention Ponds, Tanks, and Vaults

BMP F6.10 Detention Ponds

The design criteria in this section are for detention ponds. However, many of the criteria also apply to infiltration ponds (Section 6.3 and Chapter 5 – Runoff Treatment Facility Design). Detention ponds are *not* subject to UIC regulations (see Chapter 5.6).

Dam Safety for Detention BMPs

Very large stormwater detention facilities that can impound 10 acre-feet (435,600 cubic feet; 3.26 million gallons) or more with the water level at the embankment crest are subject to the state’s dam safety requirements, even if water storage is intermittent and infrequent (WAC 173-175-

020(1)). The principal safety concern is for the downstream population at risk if the dam should breach and allow an uncontrolled release of the pond contents. Peak flows from dam failures are typically much larger than the 100-year flows which these ponds are typically designed to accommodate.

Dam safety considerations generally apply only to the volume of water stored above natural ground level. Per the definition of dam height in WAC 173-175-030, natural ground elevation is measured from the downstream toe of the dam. If a trench is cut through natural ground to install an outlet pipe for a spillway or low-level drain, the natural ground elevation is measured from the base of the trench where the natural ground remains undisturbed.

The Dam Safety Office in the Department of Ecology is available to provide written guidance documents and technical assistance to project owners and design engineers in understanding and addressing the dam safety requirements for their specific project. If the pond will meet the size or depth criteria for dam safety it is requested that Dam Safety be contacted early in the facilities planning process.

Electronic versions of the guidance documents in PDF format are available on the Department of Ecology Web site at http://www.ecy.wa.gov/programs/wr/dams/dss.html.

Design Criteria

Detention ponds must meet the requirements of Core Element #6 Flow Control (see Chapter 2.6.6), particularly the release rates, and any additional requirements established by the permitting agency or local jurisdiction. To protect stream habitat, the 2-year runoff volume for the proposed development conditions must be released at a rate that does not exceed 50% of the pre-developed or existing 2-year peak flow rate. The facility should also match the 25-year peak flow rate for pre-developed or existing conditions; or it may match flow rate(s) for a different or additional recurrence interval(s) established by the permitting agency or local jurisdiction. For hydrologic analysis methods to determine these flow rates, see Chapter 4.

Standard details for detention ponds are shown in Figure 6.2.1 through Figure 6.2.3. Control structure details are provided in Section 6.2.4.

General

Ponds may be designed as flow-through systems (however, parking lot storage may be utilized through a back-up system; see Section 6.2.5). Developed flows must enter through a conveyance system separate from the control structure and outflow conveyance system. Maximizing distance between the inlet and outlet is encouraged to promote sedimentation.

Pond bottoms should be level and be located a minimum of 0.5 foot (preferably 1 foot) below the inlet and outlet to provide sediment storage.

The design professional should carefully consider and evaluate any situation where a pond will be situated upslope from a structure or behind the top of a slope inclined in excess of 15 percent. Check local critical area ordinances for unstable slopes. The minimum setback from such a slope is greater than or equal to the height of the slope, unless the design professional can justify a lesser setback based on a comprehensive site evaluation.

Side Slopes

Interior side slopes up to the emergency overflow water surface should not be steeper than 3H:1V unless a fence is provided (see “Fencing”).

Exterior side slopes should not be steeper than 2H:1V unless analyzed for stability by a geotechnical engineer.

Pond walls may be vertical retaining walls, provided: (a) they are constructed of reinforced concrete; (b) a fence is provided along the top of the wall; (c) the entire pond perimeter may be retaining walls, however, it is recommended that at least 25 percent of the pond perimeter be a vegetated soil slope not steeper than 3H:1V; and (d) the design is stamped by a licensed civil engineer with structural expertise. Other retaining walls such as rockeries, concrete, masonry unit walls, and keystone type wall may be used if designed by a geotechnical engineer or a civil engineer with structural expertise. If the entire pond perimeter is to be retaining walls, ladders should be provided on the walls for safety reasons.

Embankments

Pond berm embankments higher than 6 feet must be designed by a professional engineer with geotechnical expertise.

For berm embankments 4 feet high or less, the minimum top width should be 4 feet or as recommended by a geotechnical engineer.

Pond berm embankments must be constructed on native consolidated soil (or adequately compacted and stable fill soils analyzed by a geotechnical engineer) free of loose surface soil materials, roots, and other organic debris.

Pond berm embankments greater than 4 feet in height must be constructed by excavating a key equal to 50 percent of the berm embankment cross-sectional height and width unless specified otherwise by a geotechnical engineer.

Embankment compaction should be accomplished in such a manner as to produce a dense, low permeability engineered fill that can tolerate post-construction settlements with a minimum of cracking. The embankment fill should be placed on a stable sub-grade and compacted to a minimum of 95% of the Modified Proctor Maximum Density, ASTM Procedure D1557. Placement moisture content should lie within 1% dry to 3% wet of the optimum moisture content. The referenced degree of compaction may have to be increased to comply with local regulations.

The berm embankment should be constructed of soils with the following characteristics: a minimum of 20% silt and clay, a maximum of 60% sand, a maximum of 60% silt, with nominal gravel and cobble content. Soils outside this specified range can be used, provided the design satisfactorily addresses the engineering concerns posed by these soils. The paramount concerns with these soils are their susceptibility to internal erosion or piping and to surface erosion from wave action and runoff on the upstream and downstream slopes, respectively. Anti-seepage filter-drain diaphragms must be placed on outflow pipes in berm embankments impounding water with depths greater than 8 feet at the design water surface. See Dam Safety Guidelines at www.ecy.wa.gov/programs/wr/dams/dss.html.

Overflow

1. In all ponds, tanks, and vaults, a primary overflow (usually a riser pipe within the control structure; see Section 6.2.4) must be provided to bypass the 25-year developed peak flow over or around the restrictor system. This assumes the facility will be full due to plugged orifices or high inflows; the primary overflow is intended to protect against breaching of a pond embankment (or overflows of the upstream conveyance system in the case of a detention tank or vault). The design must provide controlled discharge directly into the downstream conveyance system or another acceptable discharge point.

2. A secondary inlet to the control structure should be provided in ponds as additional protection against overtopping should the inlet pipe to the control structure become plugged. A grated opening ("jailhouse window") in the control structure manhole functions as a weir (see Figure 6.2.2) when used as a secondary inlet.

   Note*: The maximum circumferential length of this opening must not exceed one-half the control structure circumference.* The "birdcage" overflow structure as shown in Figure 6.2.3 may also be used as a secondary inlet.

Emergency Overflow Spillway

Emergency overflow spillways are intended to control the location of pond overtopping in the event of total control structure failure (e.g., blockage of the control structure outlet pipe) or extreme inflows, and direct overflows back into the downstream conveyance system or other acceptable discharge point.

Emergency overflow spillways must be provided for ponds with constructed berms over 2 feet in height, or for ponds located on grades in excess of 5 percent. As an option for ponds with berms less than 2 feet in height and located at grades less than 5 percent, emergency overflow may be provided by an emergency overflow structure, such as a manhole fitted with a birdcage as shown in Figure 6.2.3. The emergency overflow structure must be designed to pass the 25-year developed peak flow, with a minimum 6 inches of freeboard, directly to the downstream conveyance system or another acceptable discharge point. Where an emergency overflow spillway would discharge to a steep slope, consideration should be given to providing an emergency overflow structure in addition to the spillway.

The emergency overflow spillway must be armored with riprap or other suitable material. The spillway must be armored full width, beginning at a point midway across the berm embankment and extending downstream to where emergency overflows re-enter the conveyance system (see Figure 6.2.2). Guidance for the design of the riprap can be found in HEC-11, "Design of Riprap Revetment," and HEC-14, "Hydraulic Design of Energy Dissipators for Culverts and Channels."

Emergency overflow spillway designs should be analyzed as broad-crested trapezoidal weirs.

Access

The following guidelines for access may be used.

Maintenance access road(s) should be provided to the control structure and other drainage structures associated with the pond (e.g., inlet or bypass structures). It is recommended that manhole and catch basin lids be in or at the edge of the access road and at least three feet from a property line.

An access ramp is needed for removal of sediment with a trackhoe and truck. The ramp should extend to the pond bottom if the pond bottom is greater than 1,500 square feet (measured without the ramp) and it may end at an elevation 4 feet above the pond bottom, if the pond bottom is less than 1,500 square feet (measured without the ramp).

On large, deep ponds, truck access to the pond bottom via an access ramp is necessary so loading can be done in the pond bottom. On small deep ponds, the truck can remain on the ramp for loading. On small shallow ponds, a ramp to the bottom may not be required if the trackhoe can load a truck parked at the pond edge or on the internal berm of a wetpond or combined pond (trackhoes can negotiate interior pond side slopes).

Access ramps must meet the requirements for design and construction of access roads specified below.

If a fence is required, access should be limited by a double-posted gate or by bollards – that is, two fixed bollards on each side of the access road and two removable bollards equally located between the fixed bollards.

Design of Access Roads

The design guidelines for access road are given below.

- Maximum grade should be 20 percent.
- Outside turning radius should be a minimum of 40 feet.
- Fence gates should be located only on straight sections of road.

- Access roads should be 15 feet in width on curves and 12 feet on straight sections.
- The drivable surface should have a 20-year design life to carry the load of a 24 ton truck; assume 3 trips per year.
- A paved apron must be provided where access roads connect to paved public roadways.
- A truck turn-around is required at the terminus of the road.

Construction of Access Roads

Access roads may be constructed with an asphalt or gravel surface, or modular grid pavement. All surfaces must conform to the jurisdictional standards and manufacturer's specifications.

Fencing

A fence may also be needed around impoundments of open water. Refer to the Uniform Building Code or local building codes for fencing requirements in these areas.

Right-of-Way

Right-of-way may be needed for detention pond maintenance. It is recommended that any tract not abutting public right-of-way have 15-20 foot wide extension of the tract to an acceptable access location.

Setbacks

It is recommended that the ponded area be a minimum of 20 feet from any structure, property line, and any vegetative buffer required by the local government. Side slopes for the pond or berm should be a minimum of 5 feet from any structure or property line. The detention pond water surface at the pond outlet invert elevation must be set back 100 feet from proposed or existing septic system drainfields. However, the setback requirements are generally specified by the local government, Uniform Building Code, or other statewide regulation, and may be different from those mentioned above.

The design professional should carefully consider and evaluate any situation where an infiltration facility will be situated upslope from a structure or behind the top of a slope inclined in excess of 15 percent. The minimum setback from such a slope is equal to ‘h’, the height of the slope, unless the design professional can justify a lesser setback based on a comprehensive site evaluation.

Seeps and Springs

Intermittent seeps along cut slopes are typically fed by a shallow groundwater source (interflow) flowing along a relatively impermeable soil stratum. These flows are storm driven and should discontinue after a few weeks of dry weather. However, more continuous seeps and springs, which extend through longer dry periods, are likely from a deeper groundwater source. When continuous flows are intercepted and directed through flow control facilities, adjustments to the facility design may have to be made to account for the additional base flow (unless already considered in design).

Planting Requirements

Exposed earth on the pond bottom and interior side slopes may be sodded or seeded with an appropriate seed mixture. All remaining areas of the tract may be planted with grass or be landscaped. See Chapter 7 Construction Stormwater Pollution Prevention for typical seed mixes.

Landscaping

If provided, landscaping should adhere to the criteria that follow so as not to hinder maintenance operations. Landscaped stormwater tracts may, in some instances, provide a recreational space. In other instances, "naturalistic" stormwater facilities may be placed in open space tracts.

The following guidelines should be followed if landscaping is proposed for facilities.

1. No trees or shrubs may be planted within 10 feet of inlet or outlet pipes or manmade drainage structures such as spillways or flow spreaders. Species with roots that seek water, such as willow or poplar, should be avoided within 50 feet of pipes or manmade structures.
2. Planting should be restricted on berms that impound water either permanently or temporarily during storms. This restriction does not apply to cut slopes that form pond banks, only to berms.
   a) Trees or shrubs may not be planted on portions of water impounding berms taller than four feet high. Only grasses may be planted on berms taller than four feet.

      Grasses allow unobstructed visibility of berm slopes for detecting potential dam safety problems such as animal burrows, slumping, or fractures in the berm.
   b) Trees planted on portions of water-impounding berms less than 4 feet high must be small, not higher than 20 feet mature height, and have a fibrous root system.

      These trees reduce the likelihood of blow-down trees, or the possibility of channeling or piping of water through the root system, which may contribute to dam failure on berms that retain water.
3. All landscape material, including grass, should be planted in good topsoil. Native underlying soils may be made suitable for planting if amended with 4 inches of well-aged compost tilled into the subgrade. Compost used should meet specifications for Grade A compost quality as described in Ecology publication 94-38.

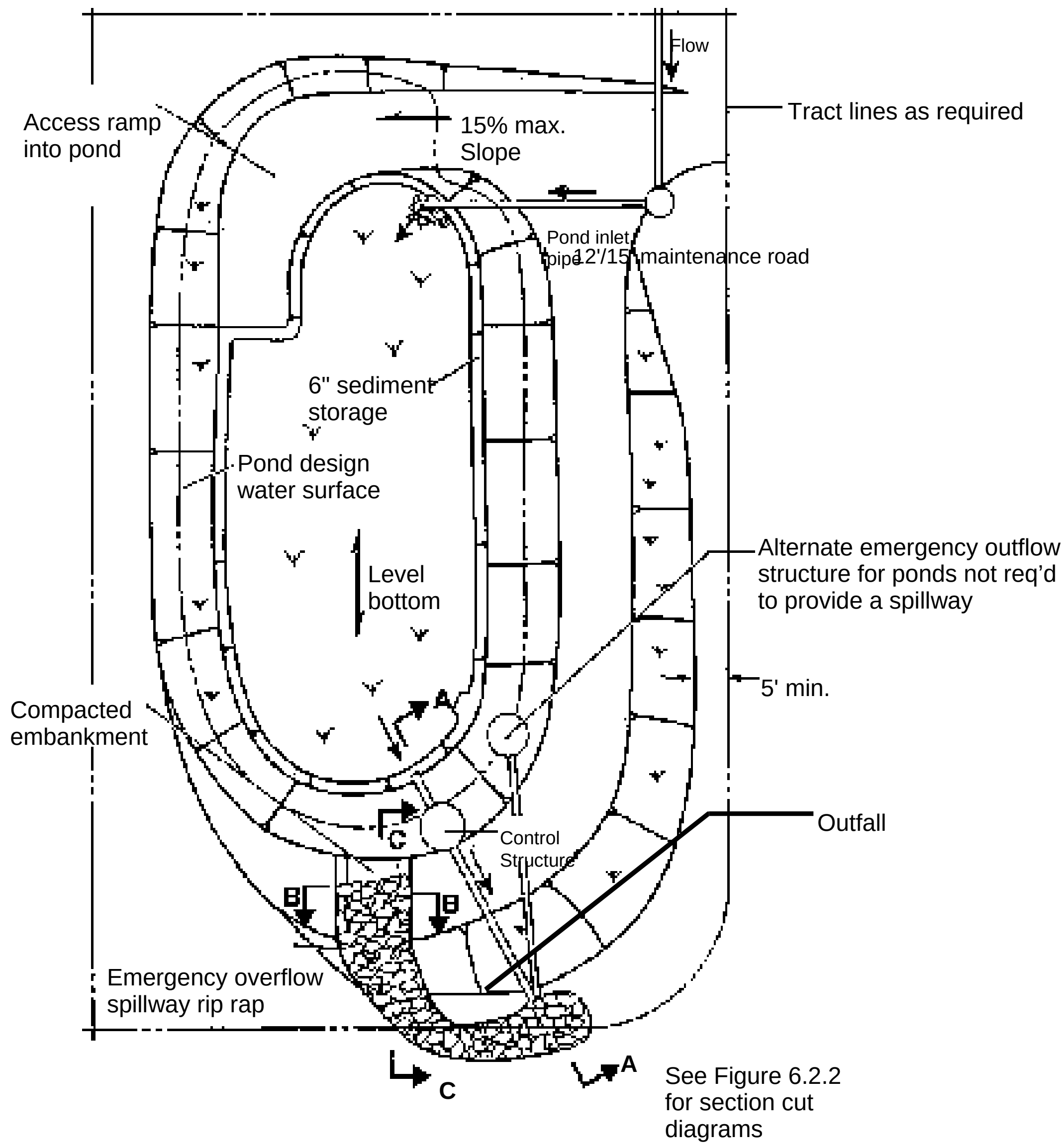
4. Soil in which trees or shrubs are planted may need additional enrichment or additional compost top-dressing. Consult a nurseryman, landscape professional, or arborist for site-specific recommendations.

5. For a naturalistic effect as well as ease of maintenance, trees or shrubs should be planted in clumps to form "landscape islands" rather than evenly spaced.

   The landscaped islands should be a minimum of six feet apart, and if set back from fences or other barriers, the setback distance should also be a minimum of 6 feet. Where tree foliage extends low to the ground, the six foot setback should be counted from the outer drip line of the trees (estimated at maturity). This setback allows a 6-foot wide mower to pass around and between clumps.

6. Evergreen trees and trees which produce relatively little leaf-fall (such as ash, locust, hawthorn) are preferred in areas draining to the pond.

7. Trees should be set back so that branches do not extend over the pond (to prevent leaf-drop into the water). Drought tolerant species are recommended.



Note:
This detail is a schematic representation only. Actual configuration will vary depending on specific site constraints and applicable design criteria.

Figure 6.2.1 – Typical detention pond

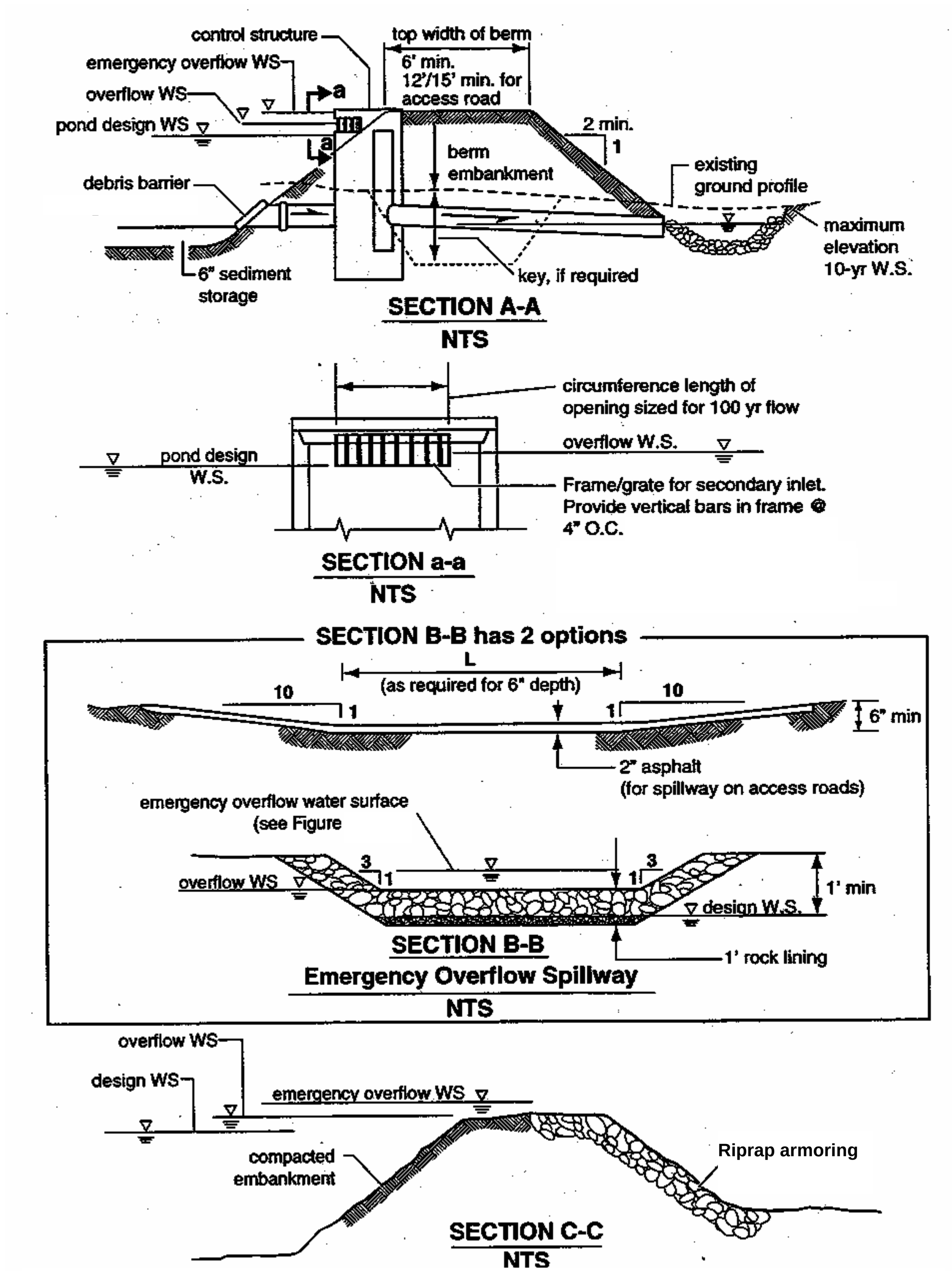
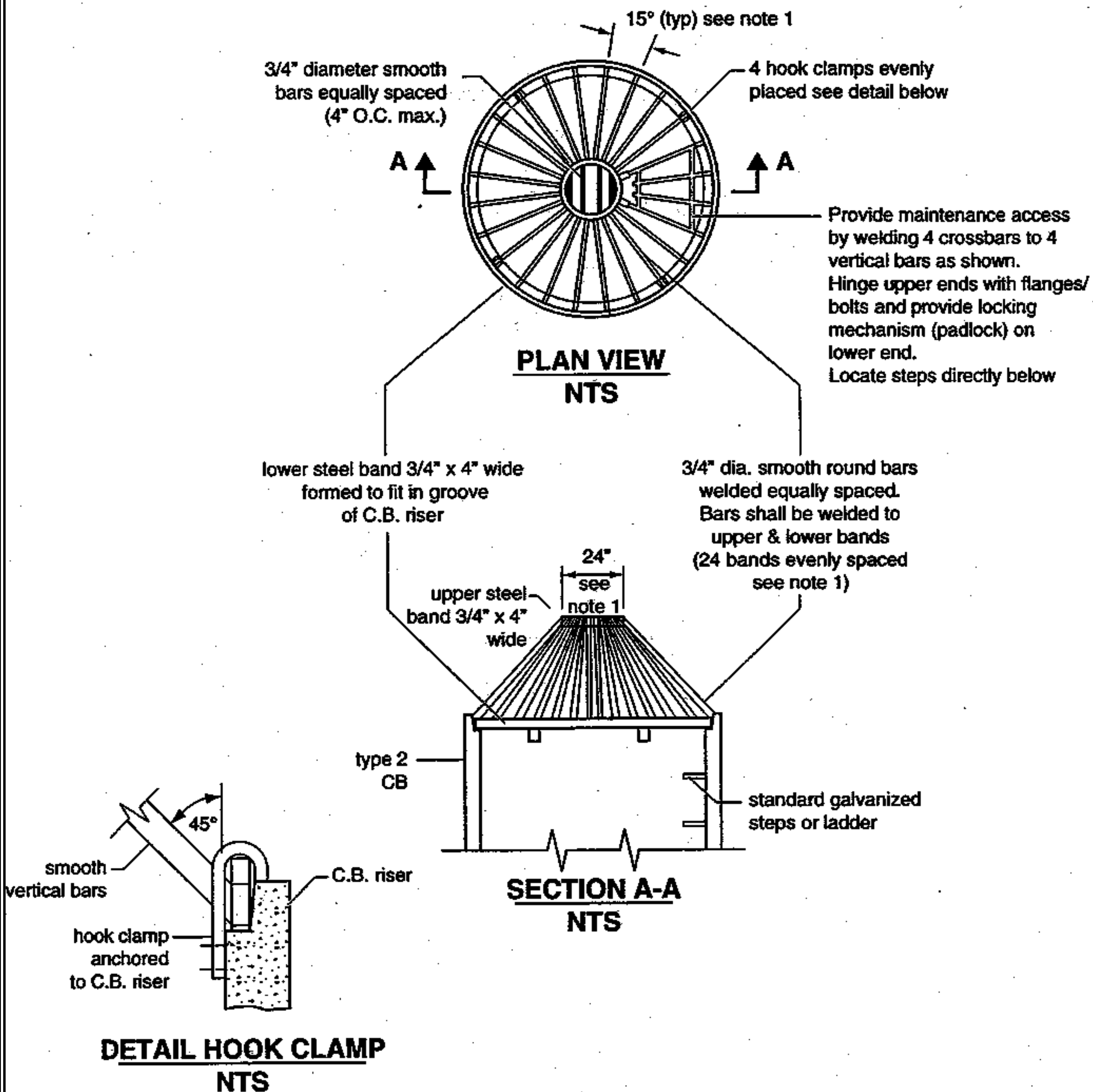


Figure 6.2.2 – Typical Detention Pond Sections



NOTES:

1. Dimensions are for illustration on 54" diameter CB For different diameter CB's adjust to maintain 45° angle on "vertical" bars and 7" o.c. maximum spacing of bars around lower steel band.
2. Metal parts must be corrosion resistant; steel bars must be galvanized.
3. This debris barrier is also recommended for use on the inlet to roadway cross-culverts with high potential for debris collection

Figure 6.2.3 – Overflow Structure

Maintenance

General. Maintenance is of primary importance if detention ponds are to continue to function as originally designed. A local government, a designated group such as a homeowners' association, or some individual should accept the responsibility for maintaining the structures and the impoundment area. A specific maintenance plan should be formulated outlining the schedule and scope of maintenance operations. Debris removal in detention basins can be achieved through the use of trash racks or other screening devices.

Design with maintenance in mind. Good maintenance will be crucial to successful use of the impoundment. Hence, provisions to facilitate maintenance operations must be built into the project when it is installed. Maintenance should be a basic consideration in design and in determination of first cost. See Appendix 6A for specific maintenance requirements.

Any standing water removed during the maintenance operation must be disposed of to a sanitary sewer at an approved discharge location. Pretreatment may be necessary. Residuals must be disposed of in accordance with state and local solid waste regulations (See Minimum Functional Standards For Solid Waste Handling, Chapter 173-304 WAC).

Vegetation. If a shallow marsh is established, then periodic removal of dead vegetation may be necessary. Since decomposing vegetation can release pollutants captured in the detention pond, especially nutrients, it may be necessary to harvest dead vegetation annually prior to the winter season. Otherwise the decaying vegetation can export pollutants out of the pond and also can cause nuisance conditions to occur.

Sediment. Maintenance of sediment forebays and attention to sediment accumulation within the pond is extremely important. Sediment deposition should be periodically monitored in the basin. Owners, operators, and maintenance authorities should be aware that significant concentrations of metals (e.g., lead, zinc, and cadmium) as well as some organics such as pesticides, may be expected to accumulate at the bottom of these treatment facilities. Testing of sediment, especially near points of inflow, should be conducted periodically to determine the leaching potential and level of accumulation of potentially hazardous material before disposal.

Methods of Analysis

Detention Volume and Outflow. The volume and outflow design for detention ponds must be in accordance with the requirements of Core Element #6, and the hydrologic analysis and design methods in Chapter 4. Design guidelines for restrictor orifice structures are given in Section 6.2.4.

Note*: The design water surface elevation is the highest elevation which occurs in order to meet the required outflow performance for the pond.*

Detention Ponds in Infiltrative Soils. Detention ponds may occasionally be sited on soils that are sufficiently permeable for a properly functioning infiltration system. These detention ponds have a surface discharge and may also utilize infiltration as a second pond outflow. Detention ponds sized with infiltration as a second outflow must meet all the requirements of Section 6.3 for infiltration ponds, including a soils report, testing, groundwater protection, pre-settling, and construction techniques.

Emergency Overflow Spillway Capacity. For impoundments under 10-acre-feet, the emergency overflow spillway weir section must be designed to pass the 25-year runoff event for developed conditions assuming a broad-crested weir. The broad-crested weir equation for the spillway section in Figure 6.2.4, for example, would be:

$$Q_{25} = C\,(2g)^{1/2}\left[\frac{2}{3}LH^{3/2} + \frac{8}{15}(\mathrm{Tan}\,\theta)\,H^{5/2}\right] \qquad \text{(Eq. 5.2.1)}$$

Where Q_{25} = peak flow for the 25-year runoff event (cfs)

C = discharge coefficient (0.6)
g = gravity (32.2 ft/sec^2)
L = length of weir (ft)
H = height of water over weir (ft)
θ = angle of side slopes

Assuming C = 0.6 and Tan θ = 3 (for 3:1 slopes), the equation becomes:

$$Q_{25} = 3.21[LH^{3/2} + 2.4\,H^{5/2}] \qquad \text{(Eq. 5.2.2)}$$

To find length L for the weir section, the equation is rearranged to use the computed Q_{25} and trial values of H (0.2 feet minimum):

$$L = [Q_{25}/(3.21H^{3/2})] - 2.4\,H \quad \text{or 6 feet minimum} \qquad \text{(Eq. 5.2.3)}$$

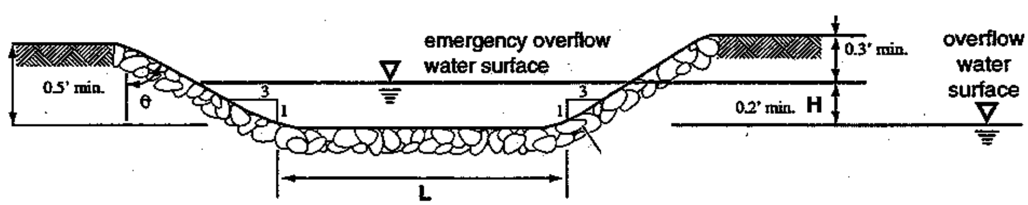


Figure 6.2.4 – Weir Section for Emergency Overflow

BMP F6.11 Detention Tanks

Detention tanks are underground storage facilities typically constructed with large diameter corrugated metal pipe. Standard detention tank details are shown in Figures 6.2.5 and 6.2.6. Control structure details are shown in Section 6.2.4. Detention tanks are not subject to UIC regulations unless the structure at the land surface is smaller than the depth of the outlet pipe *and* the pipe discharges to ground; see Chapter 5.6.

Design Criteria

General. Typical design guidelines are as follows:

1. Tanks may be designed as flow-through systems with manholes in line (see Figure 6.2.5) to promote sediment removal and facilitate maintenance. Tanks may be designed as back-up systems if preceded by water quality facilities, since little sediment should reach the inlet/control structure and low head losses can be expected because of the proximity of the inlet/control structure to the tank
2. The detention tank bottom should be located 0.5 feet below the inlet and outlet to provide dead storage for sediment.
3. The minimum pipe diameter for a detention tank is 36 inches.
4. Tanks larger than 36 inches may be connected to each adjoining structure with a short section (2-foot maximum length) of 36-inch minimum diameter pipe.

   Note*: Control and access manholes should have ladder rungs to allow ready access to all tank access pipes when the catch basin sump is filled with water*.

Materials. Pipe material, joints, and protective treatment for tanks should be in accordance with Section 9.05 of the WSDOT/APWA Standard Specification.

Structural Stability. Tanks must meet structural requirements for overburden support and traffic loading if appropriate. H-20 live loads, or other loading criteria applicable to the site, must be accommodated for tanks lying under parking areas and access roads. Metal tank end plates must be designed for structural stability at maximum hydrostatic loading conditions. Flat end plates generally require thicker gage material than the pipe and/or require reinforcing ribs. Tanks must be placed on stable, well consolidated native material with a suitable bedding. Tanks must not be placed in fill slopes, unless analyzed in a geotechnical report for stability and constructability.

Buoyancy. In moderately pervious soils where seasonal groundwater may induce flotation, buoyancy tendencies must be balanced either by ballasting with backfill or concrete backfill, providing concrete anchors, increasing the total weight, or providing subsurface drains to permanently lower the groundwater table. Calculations that demonstrate stability must be documented.

Access. The following guidelines for access may be used.

1. The maximum depth from finished grade to tank invert should be 20 feet.
2. Access openings should be positioned a maximum of 50 feet from any location within the tank.

3. All tank access openings should have round, solid locking lids (usually 1/2 to 5/8-inch diameter Allen-head cap screws).
4. 36-inch minimum diameter CMP riser-type manholes (Figure 6.2.6) of the same gage as the tank material may be used for access along the length of the tank and at the upstream terminus of the tank in a backup system. The top slab is separated (1-inch minimum gap) from the top of the riser to allow for deflections from vehicle loadings without damaging the riser tank.
5. All tank access openings must be readily accessible by maintenance vehicles.
6. Tanks must comply with the OSHA confined space requirements, which includes clearly marking entrances to confined space areas. This may be accomplished by hanging a removable sign in the access riser(s), just under the access lid.

Access Roads Access roads are needed to all detention tank control structures and risers. The access roads must be designed and constructed as specified for detention ponds in Section 6.2.1.

Right-of-Way. Right-of-way may be needed for detention tank maintenance. It is recommended that any tract not abutting public right-of-way have a 15 to 20-foot wide extension of the tract to accommodate an access road to the facility.

Setbacks. It is recommended that facilities be a minimum of 5 feet from any structure, property line, and any vegetative buffer required by the local government and from any septic drainfield. However, the setback requirements are generally specified by the local government, Uniform Building Code, or other statewide regulation and may be different from those mentioned above.

Provisions to facilitate maintenance operations must be built into the project when it is installed. Maintenance must be a basic consideration in design and in determination of first cost. See Appendix 6A for specific maintenance requirements.

Methods of Analysis

Detention Volume and Outflow. The volume and outflow design for detention tanks must be in accordance with the requirements of the regulatory agency and the hydrologic analysis and design methods in Chapter 4 - Hydrologic Analysis and Design. Restrictor and orifice design are given in Section 6.2.4.

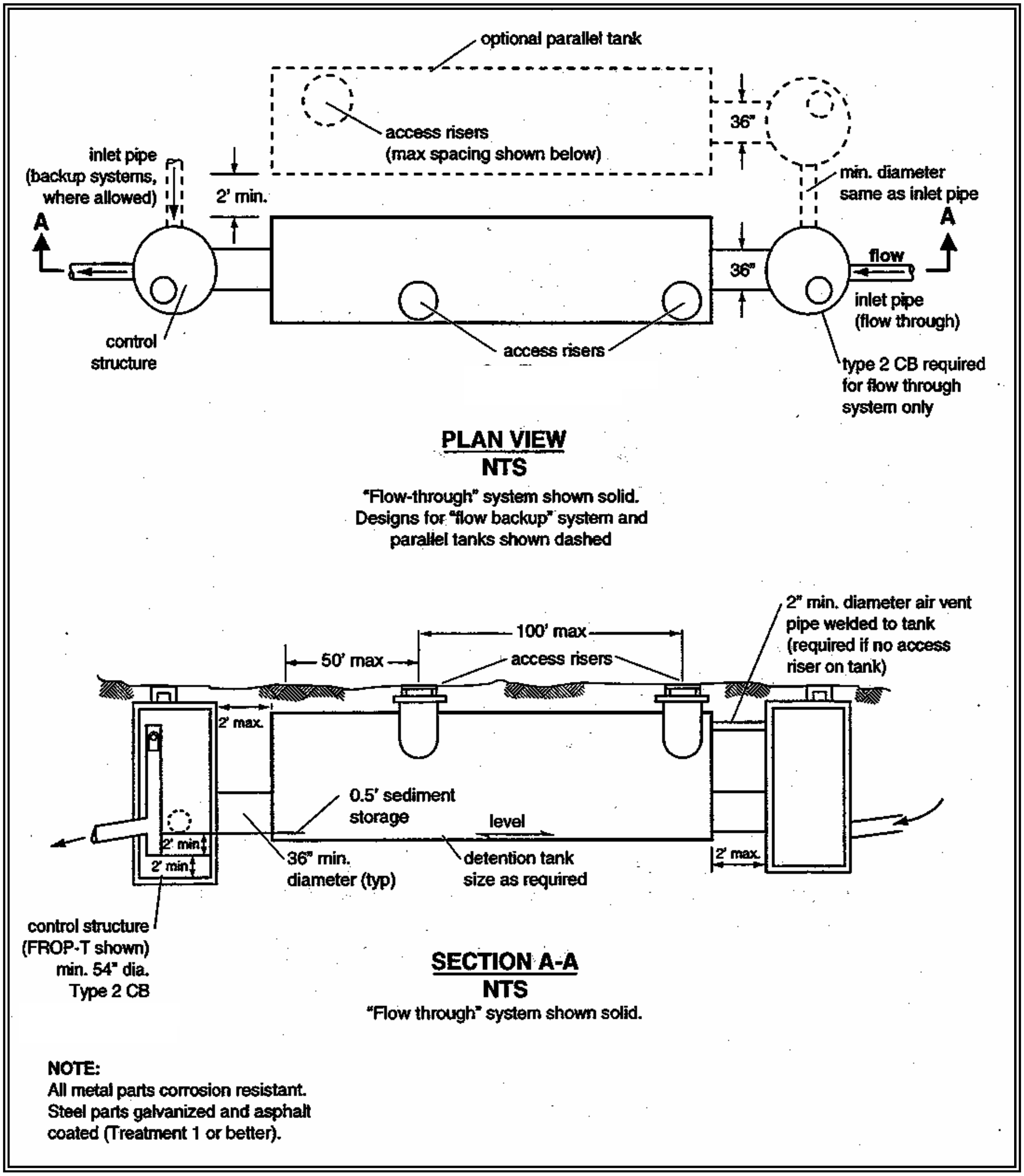


Figure 6.2.5 – Typical detention tank

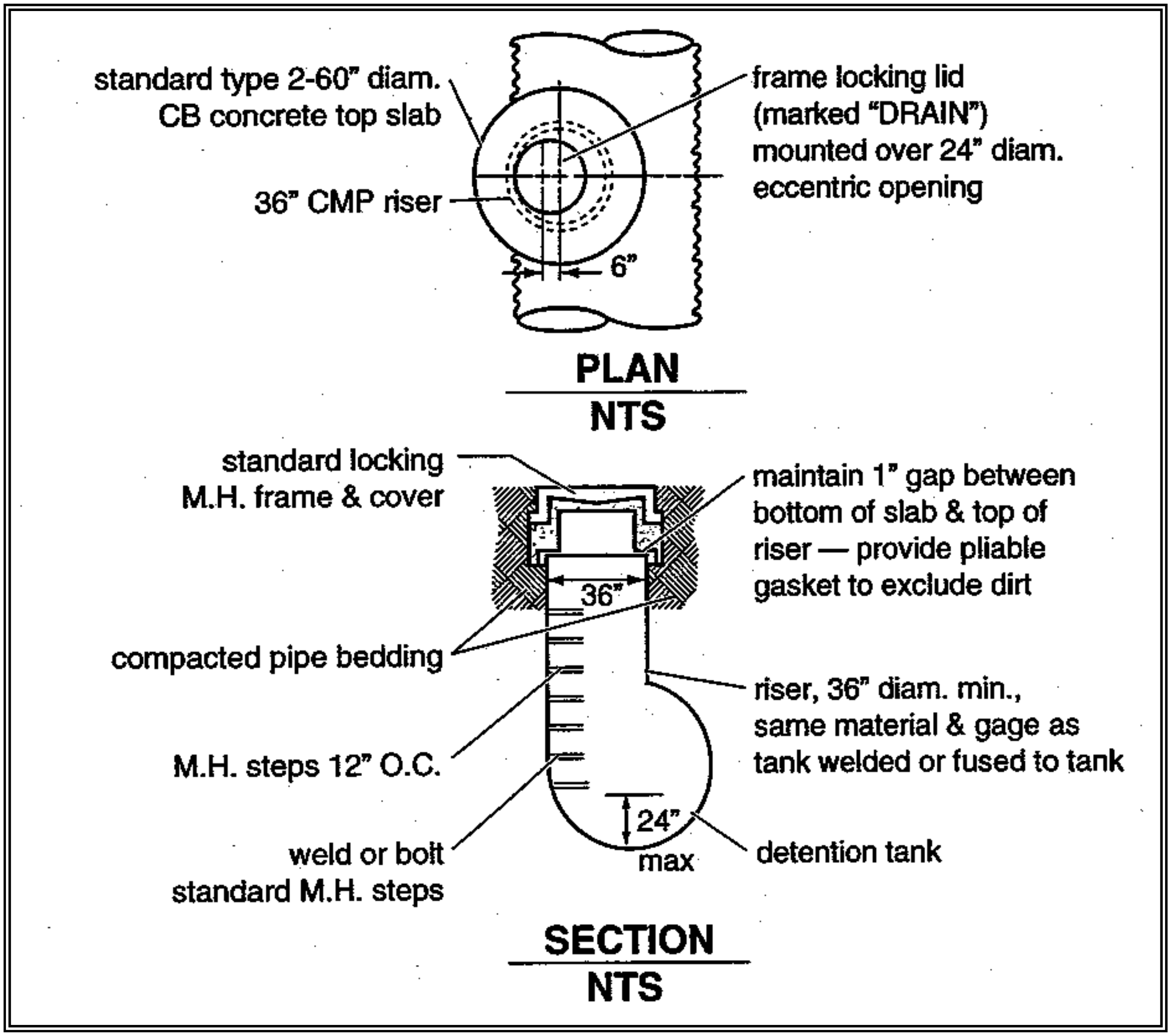


Figure 6.2.6 – Detention tank access detail

Notes for Figure 6.2.6:

Use adjusting blocks as required to bring frame to grade.
All materials to be aluminum or galvanized and asphalt coated (Treatment 1 or better).
Must be located for access by maintenance vehicles.
May substitute WSDOT special Type IV manhole (RCP only).

BMP F6.12 Detention Vaults

Detention vaults are box-shaped underground storage facilities typically constructed with reinforced concrete. A standard detention vault detail is shown in Figure 6.2.7. Control structure details are shown in Section 6.2.4. Detention vaults are not subject to UIC regulations unless the structure at the land surface is smaller than the depth of the outlet pipe *and* the pipe discharges to ground; see Chapter 5.6.

Design Criteria

General. Typical design guidelines are as follows:

1. Detention vaults may be designed as flow-through systems with bottoms level (longitudinally) or sloped toward the inlet to facilitate sediment removal. Distance between the inlet and outlet should be maximized (as feasible).
2. The detention vault bottom may slope at least 5 percent from each side towards the center, forming a broad “v” to facilitate sediment removal. More than one “v” may be used to minimize vault depth. However, the vault bottom may be flat with 0.5-1 foot of sediment storage if removable panels are provided over the entire vault. It is recommended that the removable panels be at grade, have stainless steel lifting eyes, and weigh no more than 5 tons per panel.
3. The invert elevation of the outlet should be elevated above the bottom of the vault to provide an average 6 inches of sediment storage over the entire bottom. The outlet should also be elevated a minimum of 2 feet above the orifice to retain oil within the vault.

Materials. Minimum 3,000 psi structural reinforced concrete may be used for detention vaults. All construction joints must be provided with water stops.

Structural Stability. All vaults must meet structural requirements for overburden support and H-20 traffic loading (See Standard Specifications for Highway Bridges, 1998 Interim Revisions, American Association of State Highway and Transportation Officials). Vaults located under roadways must meet any live load requirements of the local government. Cast-in-place wall sections must be designed as retaining walls. Structural designs for cast-in-place vaults must be stamped by a licensed civil engineer with structural expertise. Vaults must be placed on stable, well-consolidated native material with suitable bedding. Vaults must not be placed in fill slopes, unless analyzed in a geotechnical report for stability and constructability.

Access. Access must be provided over the inlet pipe and outlet structure. The following guidelines for access may be used.

1. Access openings should be positioned a maximum of 50 feet from any location within the tank. Additional access points may be needed on large vaults. If more than one “v” is provided in the vault floor, access to each “v” must be provided.

2. For vaults with greater than 1,250 square feet of floor area, a 5' by 10' removable panel should be provided over the inlet pipe (instead of a standard frame, grate and solid cover). Alternatively, a separate access vault may be provided.
3. For vaults under roadways, the removable panel must be located outside the travel lanes. Alternatively, multiple standard locking manhole covers may be provided. Ladders and hand-holds need only be provided at the outlet pipe and inlet pipe, and as needed to meet OSHA confined space requirements. Vaults providing manhole access at 12-foot spacing need not provide corner ventilation pipes as specified in Item 10 below.
4. All access openings, except those covered by removable panels, may have round, solid locking lids, or 3-foot square, locking diamond plate covers.
5. Vaults with widths 10 feet or less must have removable lids.
6. The maximum depth from finished grade to the vault invert should be 20 feet.
7. Internal structural walls of large vaults should be provided with openings sufficient for maintenance access between cells. The openings should be sized and situated to allow access to the maintenance "v" in the vault floor.
8. The minimum internal height should be 7 feet from the highest point of the vault floor (not sump), and the minimum width should be 4 feet. However, concrete vaults may be a minimum 3 feet in height and width if used as tanks with access manholes at each end, and if the width is no larger than the height. Also the minimum internal height requirement may not be needed for any areas covered by removable panels.
9. Vaults must comply with the OSHA confined space requirements, which includes clearly marking entrances to confined space areas. This may be accomplished by hanging a removable sign in the access riser(s), just under the access lid.
10. Ventilation pipes (minimum 12-inch diameter or equivalent) should be provided in all four corners of vaults to allow for artificial ventilation prior to entry of maintenance personnel into the vault. Alternatively removable panels over the entire vault may be provided.

Access Roads. Access roads are needed to the access panel (if applicable), the control structure, and at least one access point per cell, and they may be designed and constructed as specified for detention ponds in Section 6.2.1.

Right-of-Way. Right-of-way is needed for detention vaults maintenance. It is recommended that any tract not abutting public right-of-way should have a 15 to 20-foot wide extension of the tract to accommodate an access road to the facility.

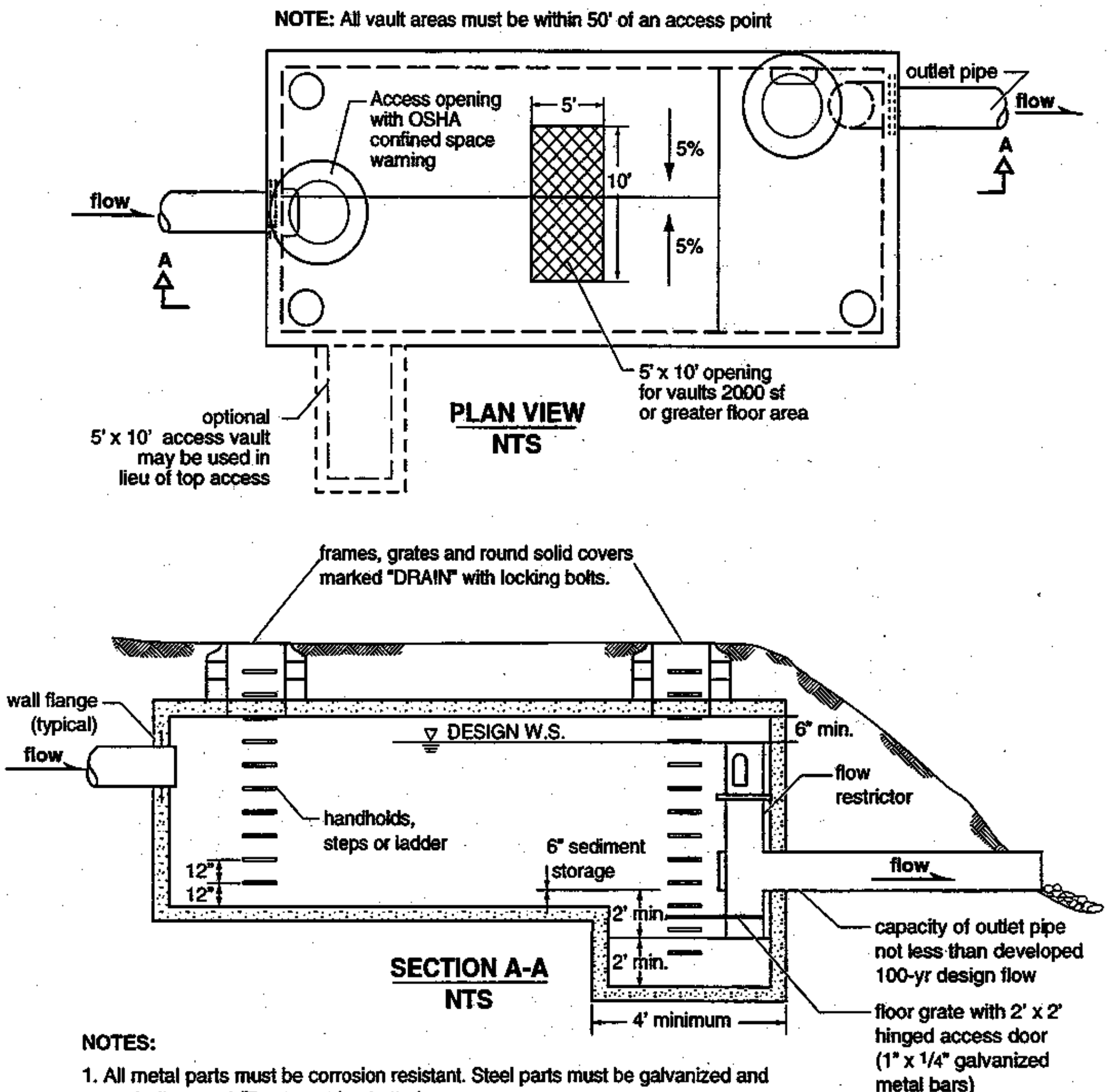
Setbacks. It is recommended that facilities be a minimum of 20 feet from any structure, property line, and any vegetative buffer required by the local government and from any septic drainfield. However, the setback requirements are generally specified by the local government, uniform building code, or other statewide regulation and may be different from those mentioned above.

The design professional should carefully consider and evaluate any situation where a pond will be situated upslope from a structure or behind the top of a slope inclined in excess of 15 percent. The minimum setback from such a slope is equal to 'h', the height of the slope, unless the design professional can justify a lesser setback based on a comprehensive site evaluation.

Maintenance. Provisions to facilitate maintenance operations must be built into the project when it is installed. Maintenance must be a basic consideration in design and in determination of first cost. See Appendix 6A for specific maintenance requirements.

Methods of Analysis

Detention Volume and Outflow. The volume and outflow design for detention vaults must be in accordance with the requirements of the regulatory agency and the hydrologic analysis and design methods in Chapter 4. Restrictor and orifice design are given in Section 6.2.4.



NOTES:

1. All metal parts must be corrosion resistant. Steel parts must be galvanized and asphalt coated (Treatment I or better).
2. Provide water stop at all cast-in-place construction joints. Precast vaults shall have approved rubber gasket system.
3. Vaults ≤ 10' wide must use removable lids.
4. Prefabricated vault sections may require structural modifications to support 5' x 10' opening over main vault. Alternatively, access can be provided via a side vestibule as shown.

Figure 6.2.7 – Typical detention vault

6.2.2 Control Structures

Control structures are catch basins or manholes with a restrictor device for controlling outflow from a facility to meet the desired performance. Riser type restrictor devices ("tees") or flow restrictor oil pollution control tees ("FROP-Ts") also provide some incidental oil/water separation to temporarily detain oil or other floatable pollutants in runoff due to accidental spill or illegal dumping.

The restrictor device usually consists of two or more orifices and/or a weir section sized to meet performance requirements.

Standard control structure details are shown in Figures 6.2.8 and 6.2.9.

Design Criteria

Multiple Orifice Restrictor. In most cases, control structures need only two orifices: one at the bottom and one near the top of the riser, although additional orifices may best utilize detention storage volume. Several orifices may be located at the same elevation if necessary to meet performance requirements.

Control Structure	**Pond Head**
outlet pipe	very low
v-notch weir	low
slotted weir	moderate
multi-stage orifice	high

A 1-inch diameter minimum orifice is recommended, but must be confirmed with the requirements of the local jurisdiction.

1. Minimum orifice diameter is 1.0 inches, subject to confirmation by the local jurisdiction. Note: In some instances, a 0.5-inch bottom orifice will be too large to meet target release rates, even with minimal head. In these cases, the live storage depth need not be reduced to less than 3 feet in an attempt to meet the performance standards. Also, under such circumstances, flow-throttling devices may be a feasible option. These devices will throttle flows while maintaining a plug-resistant opening.
2. Orifices may be constructed on a tee section as shown in Figure 6.2.8 or on a baffle as shown in Figure 6.2.9.
3. In some cases, performance requirements may require the top orifice/elbow to be located too high on the riser to be physically constructed (e.g., a 13-inch diameter orifice positioned 0.5 feet from the top of the riser). In these cases, a notch weir in the riser pipe may be used to meet performance requirements (see Figure 6.2.12).
4. Consideration must be given to the backwater effect of water surface elevations in the downstream conveyance system. High tailwater elevations may affect performance of the restrictor system and reduce live storage volumes.

Riser and Weir Restrictor.

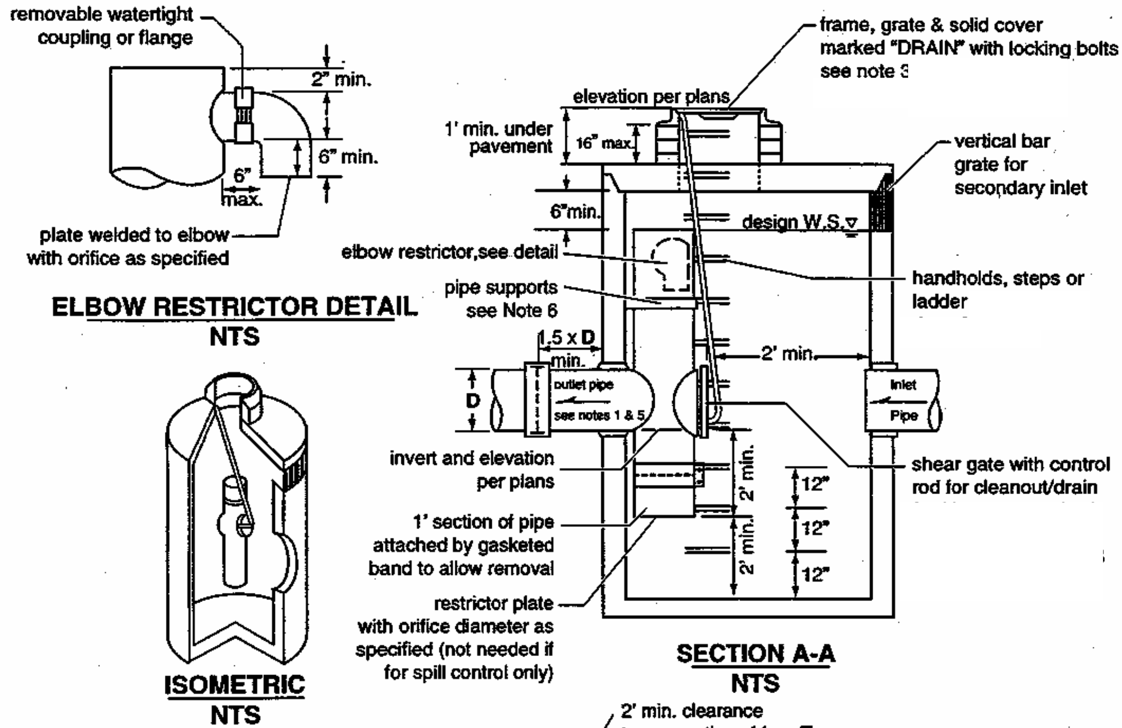
1. Properly designed weirs may be used as flow restrictors (see Figures 6.2.11 and 6.2.12). However, they must be designed to provide for primary overflow of the developed 25-year peak flow discharging to the detention facility.
2. The combined orifice and riser (or weir) overflow may be used to meet performance requirements; however, the design must still provide for primary overflow of the developed 25-year peak flow assuming all orifices are plugged. Figure 6.2.13 can be used to calculate the head in feet above a riser of given diameter and flow.

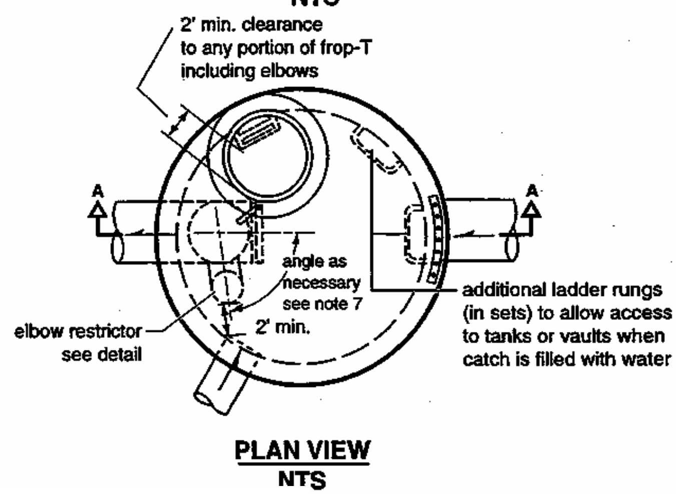
Access. The following guidelines for access may be used.

1. An access road to the control structure is needed for inspection and maintenance, and must be designed and constructed as specified for detention ponds in Section 6.2.1.
2. Manhole and catch basin lids for control structures must be locking, and rim elevations must match proposed finish grade.
3. Manholes and catch-basins must meet the OSHA and WISHA confined space requirements, which include clearly marking entrances to confined space areas. This may be accomplished by hanging a removable sign in the access riser, just under the access lid.

Information Plate. It is recommended that a brass or stainless steel plate be permanently attached inside each control structure with the following information engraved on the plate:

- Name and file number of project
- Name and company of (1) developer, (2) engineer, and (3) contractor
- Date constructed
- Date of manual used for design
- Outflow performance criteria
- Release mechanism size, type, and invert elevation
- List of stage, discharge, and volume at one-foot increments
- Elevation of overflow
- Recommended frequency of maintenance.

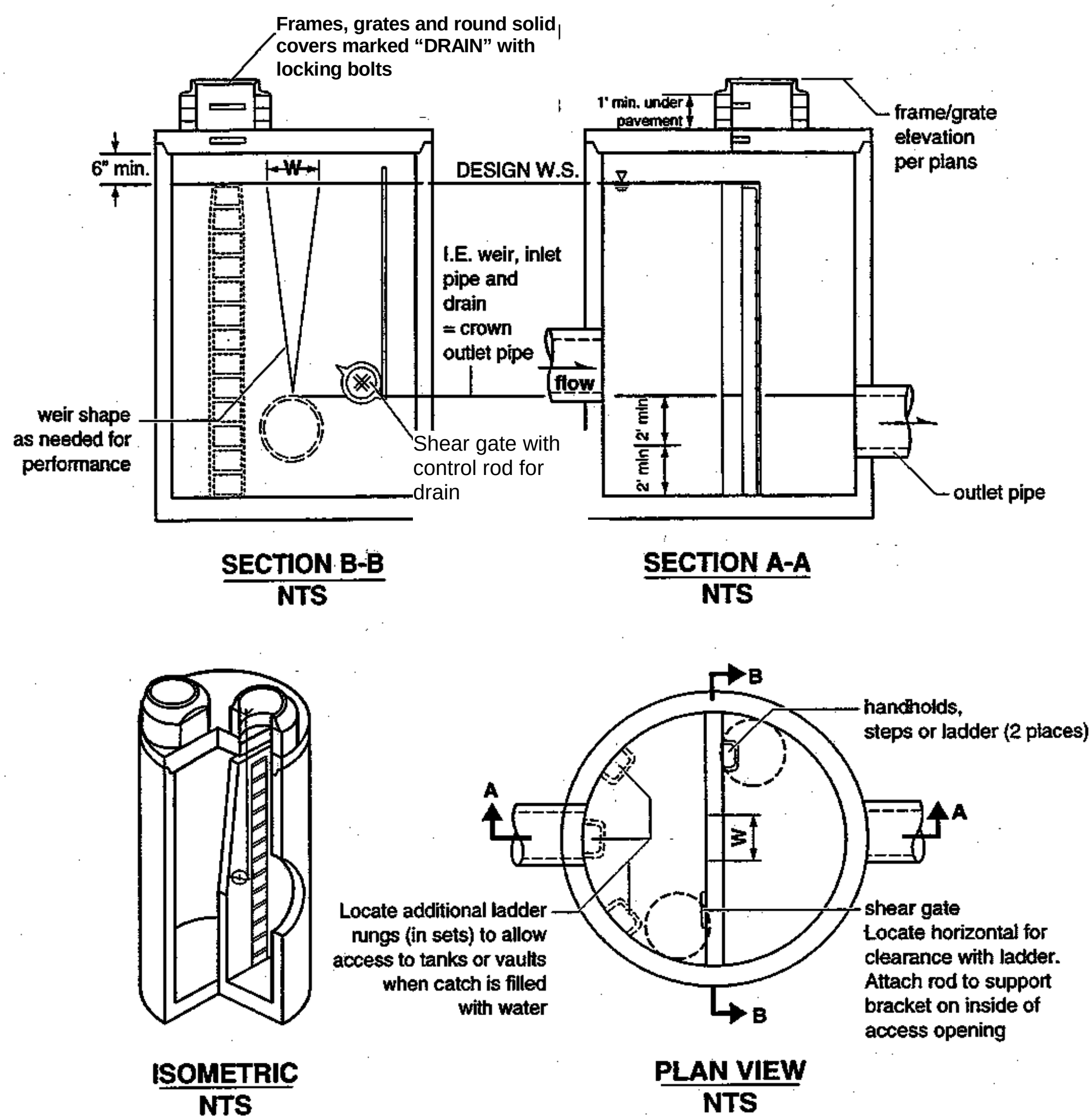




NOTES:

1. Use a minimum of a 54" diameter type 2 catch basin.
2. Outlet Capacity: 100-Year developed peak flow.
3. Metal Parts: Corrosion resistant. Non-Galvanized parts perferred. Galvanized pipe parts to have asphalt treatment 1.
4. Frame and ladder or steps offset so:
   A. Cleanout gate is visible from top.
   B. Climb-down space is clear of riser and cleanout gate.
   C. Frame is clear of curb.
5. If metal outlet pipe connects to cement concrete pipe: outlet pipe to have smooth O.D. equal to concrete pipe I.D. less 1/4"
6. Provide at least one 3" X .09 inches support bracket anchored to concrete wall. (maximum 3'-0" vertical spac...g)
7. Locate elbow restrictor(s) as necessary to provide minimum clearance as shown.
8. Locate additional ladder rungs in structures used as access to tanks or vaults to allow access when catch basin is filled with water.

Figure 6.2.8 – Flow restrictor (Tee)



NOTES:
Outlet Capacity: 100-year developed peak flow.
Metal Parts: corrosion resistant steel parts galvanized and asphalt coated.
Catch Basin: type 2 Min. 72" diameter

Baffle Wall: to be designed with concrete reinforcing as required.
Spill containment must be provided to temporarily detain oil or floatable pollutants in runoff due to accidental spill or illegal dumping.

Figure 6.2.9 – Flow Restrictor (Weir)

Maintenance. Control structures and catch basins have a history of maintenance-related problems and it is imperative that a good maintenance program be established for their proper functioning. A typical problem is that sediment builds up inside the structure which blocks or restricts flow to the inlet. To prevent this problem these structures should be routinely cleaned out. Regular inspections of control structures should be conducted to detect the need for non-routine cleanout, especially if construction or land-disturbing activities are occurring in the contributing drainage area.

A 15-foot wide access road to the control structure should be installed for inspection and maintenance. Appendix 6A provides maintenance recommendations for control structures and catch basins.

Methods of Analysis

This section presents the methods and equations for design of control structure restrictor devices. Included are details for the design of orifices, rectangular sharp-crested weirs, v-notch weirs, sutro weirs, and overflow risers.

Orifices. Flow-through orifice plates in the standard tee section or turn-down elbow may be approximated by the general equation:

$$Q = C\,A\sqrt{2gh} \qquad \text{(Eq. 5.2.4)}$$

where Q = flow (cfs)
C = coefficient of discharge (0.62 for plate orifice)
A = area of orifice (ft^2)
h = hydraulic head (ft)
g = gravity (32.2 ft/sec^2)

Figure 6.2.10 illustrates this simplified application of the orifice equation.

The diameter of the orifice is calculated from the flow. The orifice equation is often useful when expressed as the orifice diameter in inches:

$$d = \sqrt{\frac{36.88Q}{\sqrt{h}}} \qquad \text{(Eq. 5.2.5)}$$

where *d* = orifice diameter (inches)
Q = flow (cfs)
h = hydraulic head (ft)

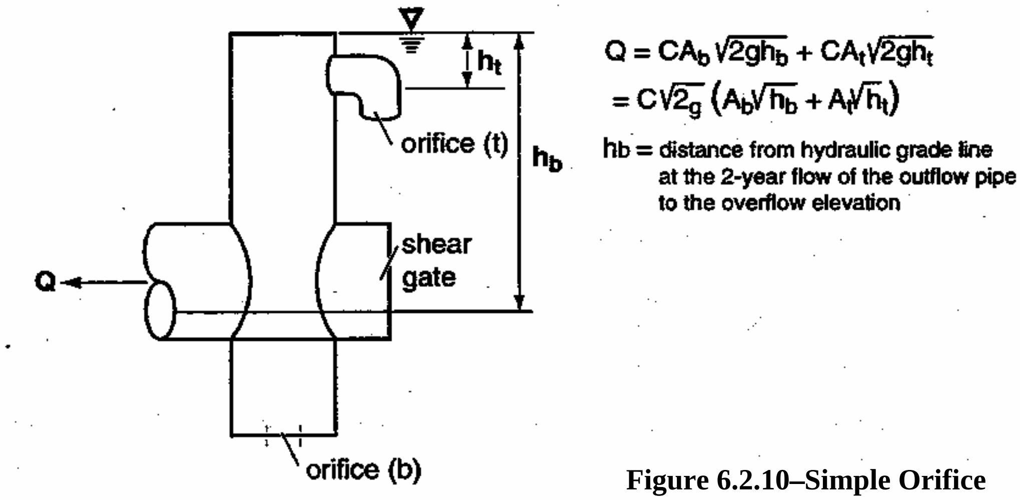


Figure 6.2.10–Simple Orifice

Rectangular Sharp-Crested Weir. The rectangular sharp-crested weir design shown in Figure 6.2.11 may be analyzed using standard weir equations for the fully contracted condition.

$$Q=C\,(L - 0.2H)H^{3/2} \qquad \text{(Eq. 5.2.6)}$$

where Q = flow (cfs)
C = 3.27 + 0.40 H/P (ft)
H, P are as shown below
L = length (ft) of the portion of the riser circumference as necessary, not to exceed 50 percent of the circumference
D = inside riser diameter (ft)

Note *that this equation accounts for side contractions by subtracting 0.1H from L for each side of the notch weir.*

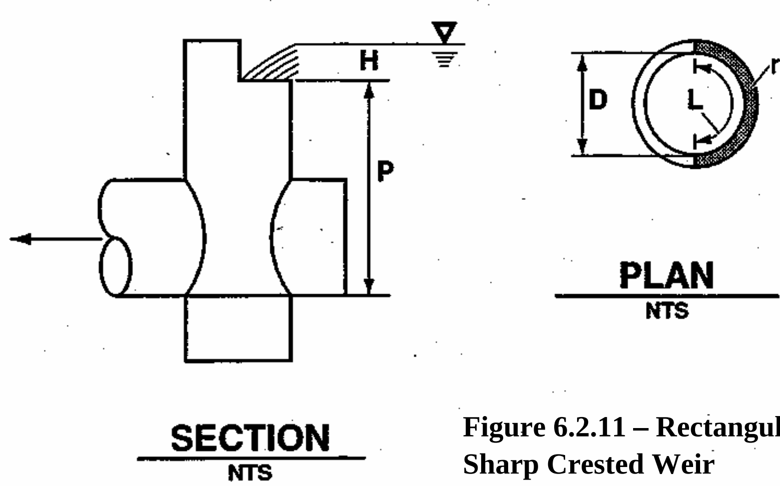
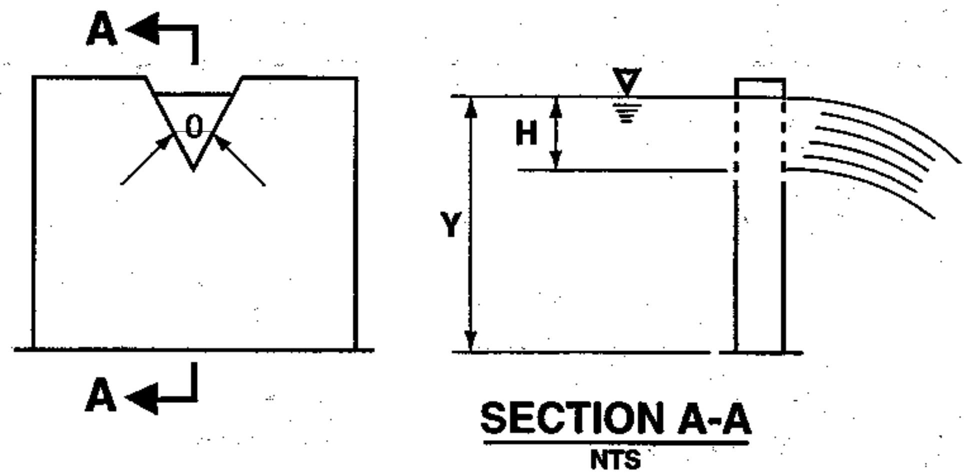


Figure 6.2.11 – Rectangular, Sharp Crested Weir

V-Notch Sharp-Crested Weir. V-notch weirs as shown in Figure 6.2.12 may be analyzed using standard equations for the fully contracted condition.



$$Q = C_d\ (\text{Tan}\ \theta/2)\ H^{5/2}\text{, in cfs}$$

Where values of C_d may be taken from the following chart:

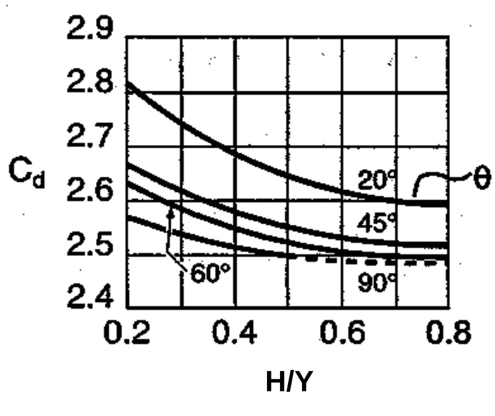


Figure 6.2.12 – V-Notch, sharp-crested weir

Riser Overflow. The nomograph in Figure 6.2.13 can be used to determine the head (in feet) above a riser of given diameter and for a given flow (usually the 25- to 100-year peak flow for developed conditions).

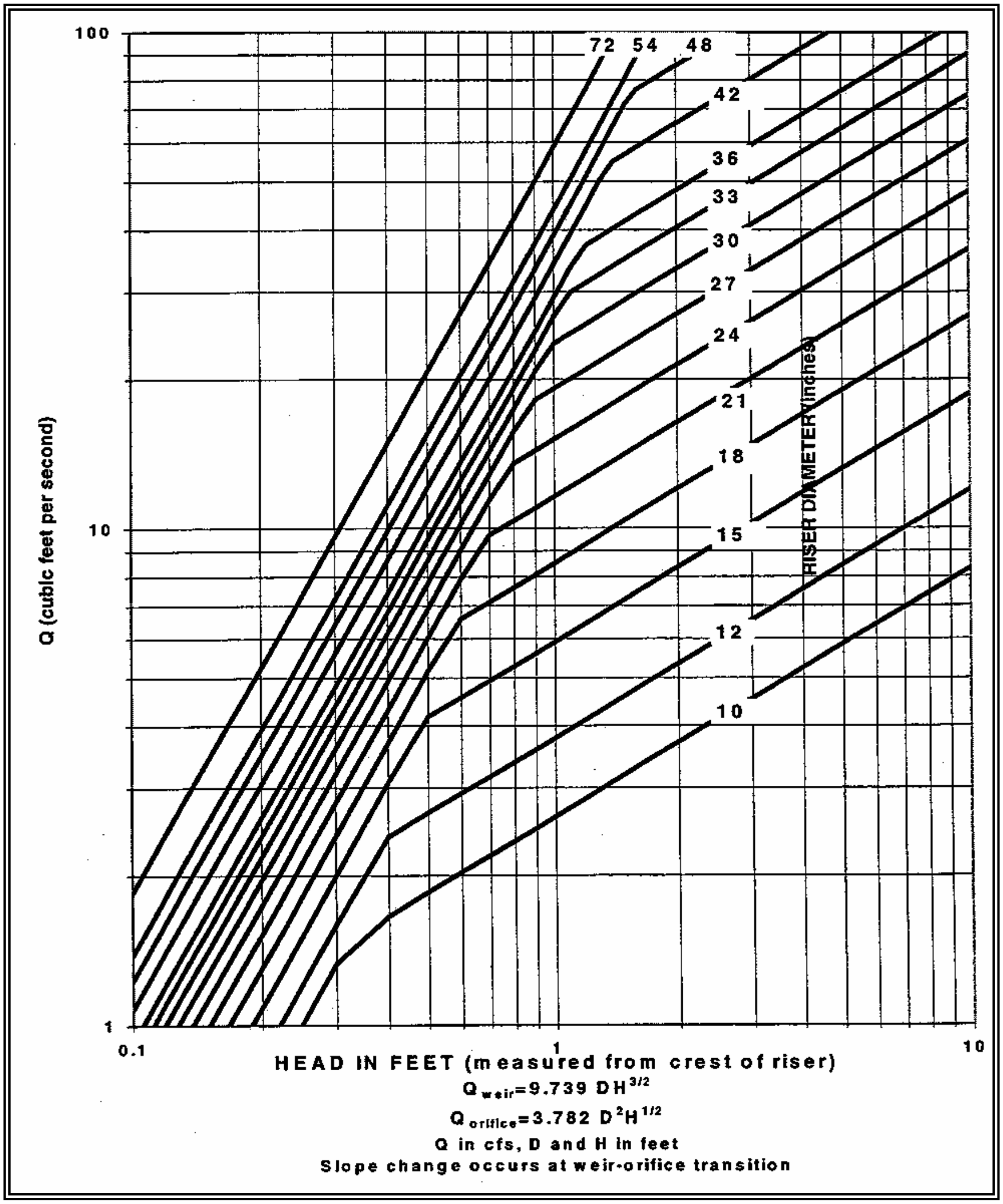


Figure 6.2.13 – Riser inflow curves

6.2.3 Supplemental Guidelines for Detention

Use of Parking Lots for Additional Detention

Parking lots may be used to provide additional detention volume for runoff events greater than the design storm, provided all of the following are met:

1. The depth of water detained does not exceed 1 foot (or other depth established by the permitting authority or local jurisdiction) at any location in the parking lot for runoff events up to and including the 100-year event.
2. The gradient of the parking lot area subject to ponding is 1 percent or greater.
3. The emergency overflow path is identified and noted on the engineering plan. The overflow must not create a significant adverse impact to downhill properties or drainage system.
4. Fire lanes used for emergency equipment are free of ponding water for all runoff events up to and including the 100-year event.
5. A downstream treatment facility with absorptive oil removal is needed prior to discharge to surface or ground water.

6.3 Infiltration of Stormwater for Quantity Control

6.3.1 Description

An infiltration BMP is typically an open basin (pond), trench, or buried perforated pipe used for distributing the stormwater runoff into the underlying soil (See Figure 6.3.2). Stormwater drywells receiving uncontaminated or properly treated stormwater can also be considered as infiltration facilities. (See Underground Injection Control Program, Chapter 173-218 WAC and Chapter 5.6 in this Manual).

Coarser more permeable soils can be used for quantity control provided that the stormwater discharge does not cause a violation of ground water quality criteria. Treatment for removal of TSS, oil, and/or soluble pollutants may be necessary prior to conveyance to an infiltration BMP. Companion practices, such as street sweeping, catch basin inserts, and similar BMPs can provide additional benefit, and reduce the cleaning and maintenance needs for the infiltration facility. The hydraulic design goal should be to mimic the natural hydrologic balance between surface and groundwater.

6.3.2 Applications

Infiltration facilities are used to convey stormwater runoff from new development or redevelopment to the ground and ground water after appropriate treatment. Runoff in excess of the infiltration capacity must be detained and released in compliance with the flow control requirements of the local jurisdiction.

Infiltration facilities may be used for quantity control where treatment is not required or for flows greater than the water quality design storm, or where runoff is treated prior to discharge. See Susceptibility Rating Tables 5.6.1 to 5.6.3 and the matrix of treatment requirements in Table 5.6.4 for determining when treatment is required prior to infiltration.

Discharge of uncontaminated or properly treated stormwater to drywells must be done in compliance with Ecology's UIC regulations (Chapter 173-218 WAC); see Chapter 5.6.

Benefits of infiltration include:

- Ground water recharge
- Retrofits in limited land areas: Infiltration trenches can be considered for residential lots, commercial areas, parking lots, and open space areas.
- Flood control
- Streambank erosion control

Site Suitability Criteria (SSC)

Not all sites are suitable for infiltration facilities. The following Site Suitability Criteria should be considered when evaluating a site for its ability to utilize infiltration.

SSC-1 Setback Criteria

Setback requirements are generally required by local regulations, uniform building code requirements, or other state regulations.

These Setback Criteria are provided as guidance.

- Stormwater infiltration facilities should be set back at least 100 feet from drinking water wells, septic tanks or drainfields, and springs used for public drinking water supplies. Infiltration facilities upgradient of drinking water supplies and within 1, 5, and 10-year time of travel zones, and special zones, must comply with Health Dept. requirements (Washington Wellhead Protection Program, DOH, 12/93).
- Additional setbacks must be considered if roadway deicers or herbicides are likely to be present in the influent to the infiltration system
- From building foundations; ≥20 feet downslope and ≥100 feet upslope
- From a Native Growth Protection Easement (NGPE); ≥20 feet
- The design professional should carefully consider and evaluate any situation where a pond will be situated upslope from a structure or behind the top of a slope inclined in excess of 15 percent. The minimum setback from such a slope is equal to 'h', the height of the slope, unless the design professional can justify a lesser setback based on a comprehensive site evaluation.

- Evaluate on-site and off-site structural stability due to extended sub-grade saturation and/or head loading of the permeable layer, including the potential impacts to down-gradient properties, especially on hills with known side-hill seeps.

SSC-2 Ground Water Protection Areas

A site is not suitable if the infiltration facility will cause a violation of Ecology's Ground Water Quality Standards. Local jurisdictions should be consulted for applicable pollutant removal requirements upstream of the infiltration facility, and to determine whether the site is located in an aquifer sensitive area, sole source aquifer, or a wellhead protection zone.

SSC-3 High Vehicle Traffic Areas

An infiltration BMP may be considered for runoff from areas of industrial activity and the high vehicle traffic areas described below. For such applications sufficient pollutant removal (including oil removal) must be provided upstream of the infiltration facility to ensure that ground water quality standards will not be violated and that the infiltration facility is not adversely affected.

High Vehicle Traffic Areas are:

- Commercial or industrial sites subject to an expected average daily traffic count (ADT) ≥100 vehicles/1,000 ft^2 gross building area (trip generation), and
- Road intersections with an ADT of ≥ 25,000 on the main roadway, or ≥ 15,000 on any intersecting roadway.

SSC-4 Soil Infiltration Rate/Drawdown Time

Design to completely drain ponded runoff within 72 hours after flow to it has stopped.

SSC-5 Depth to Bedrock, Water Table, or Impermeable Layer

The base of all infiltration basins or trench systems should be ≥ 5 feet above the seasonal high-water mark, bedrock (or hardpan) or other low permeability layer. A separation down to 3 feet may be considered if the ground water mounding analysis, volumetric receptor capacity, and the design of the overflow and/or bypass structures are judged by the design professional to be adequate to prevent overtopping and meet the site suitability criteria specified in this section.

SSC-6 Previously contaminated soils or unstable soils

The design professional should investigate whether the soil under the proposed infiltration facility has contaminants that could be transported by infiltrate from the facility. If so, measures should be taken for remediation of the site prior to construction of the facility, or an alternative location should be chosen. The designer should also determine if the soil beneath the proposed infiltration facility is unstable, due to improper placement of fill, subsurface geologic features, etc. If so, further investigation and planning should be undertaken prior to siting of the facility.

6.3.3 Determination of Infiltration Rates

Many qualitative and quantitative procedures have been developed to estimate the infiltration rates of soils, including those created by the American Society for Testing and Materials (ASTM), the Soil Conservation Service (SCS), American Association of State Highway and Transportation Officials (AASHTO), and the Bureau of Reclamation. Common field and laboratory test procedures include the constant-head permeability test, test pits, and the borehole percolation test.

A reliable, cost-effective approach to estimating infiltrative capacities of soils is based on standard laboratory grain size analysis (ASTM D2487-90) and/or Atterberg limits determinations (ASTM D4318-84), in conjunction with the ASTM D2488-90 visual/manual procedure. Guidance for conducting geotechnical studies that support presumptive infiltration rates are contained in Appendix 6B. Infiltration rates for surface BMPs are shown in Table 5.4.1.

6.3.4 General Design, Maintenance, and Construction Criteria for Infiltration Facilities

This section covers design, construction and maintenance criteria that apply to subsurface infiltration facilities such as drywells, infiltration basins, and trenches.

Design Criteria – Sizing Facilities

The size of the infiltration facility can be determined by routing the appropriate stormwater runoff through it. To prevent the onset of anaerobic conditions, the infiltration facility must be designed to drain completely 72 hours after the flow to it has stopped.

Inflow to infiltration facilities is calculated according to the methods described in Chapter 4. The storage volume in the pond, drywell, perforated pipe, or voids in the gravel, is used to detain runoff prior to infiltration. The infiltration rate and size of the infiltration area are used in conjunction with the size of the storage area to design the facility.

In general, an infiltration facility should have two discharge modes. The primary mode of discharge from an infiltration facility is infiltration into the ground. However, when the infiltration capacity of the facility is reached, additional runoff to the facility will cause the facility to overflow. Overflows from an infiltration facility must comply with the requirements of the local jurisdiction.

Additional Design Criteria

Slope of the base of the infiltration facility should be less than 3 percent.

Spillways/Overflow structures- A nonerodible outlet or spillway with a firmly established elevation must be constructed to discharge overflow. Ponding depth, drawdown time, and storage volume are calculated from that reference point.

Construction Criteria

Excavate infiltration trenches and basins to final grade only after construction has been completed and all upgradient soil has been stabilized. Initial basin excavation should be conducted to within 1-foot of the final elevation of the basin floor. Any accumulation of silt in the infiltration facility must be removed before putting it in service. After construction is completed, prevent sediment from entering the infiltration facility by first conveying the runoff water through an appropriate pretreatment system such as a pre-settling basin, wet pond, or sand filter.

Infiltration facilities should generally not be used as temporary sediment traps during construction. If an infiltration facility is to be used as a sediment trap, it must not be excavated to final grade until after the upgradient drainage area has been stabilized.

Traffic Control - Relatively light-tracked equipment is recommended for this operation to avoid compaction of the basin floor. The use of draglines and trackhoes should be considered for constructing infiltration basins. The infiltration area should be flagged or marked to keep heavy equipment away.

Maintenance Criteria

Provision should be made for regular and perpetual maintenance of the infiltration basin/trench, with adequate access. Maintenance should be conducted when water remains in the basin or trench for more than 72 hours. An Operation and Maintenance Plan, approved by the local jurisdiction, should ensure maintaining the desired infiltration rate.

Debris/sediment accumulation- Removal of accumulated debris/sediment in the basin/trench should be conducted every 6 months or as needed to prevent clogging, or when water remains in the pond for greater than 72 hours.

Seepage Analysis and Control – Determine whether there would be any adverse effects caused by seepage zones on nearby building foundations, basements, roads, parking lots or sloping sites.

Verification of Performance

During the initial operation, verification of facility performance is recommended, along with a maintenance program that results in achieving expected performance levels. Operating and maintaining ground water monitoring wells is also encouraged.

6.3.5 Infiltration Facilities

BMP F6.20 Drywells

This section covers design and maintenance criteria specific for drywells. Drywells are subject to UIC regulations; see Chapter 5.6.

Description

Drywells are subsurface concrete structures, typically precast, that convey stormwater runoff into the soil matrix. They can be used as standalone structures, or as part of a larger drainage system (i.e., the overflow for a bio-infiltration swale).

Design Criteria for Infiltration Drywells

Figures 6.3.1 through 6.3.3 show infiltration drywell systems typical at the time of publication of this document. These systems are designed as specified below. Check with the local jurisdiction for outflow capacity requirements.

Drywell bottoms should be a minimum of 5 feet above seasonal high groundwater level or impermeable soil layers. Refer to the Site Suitability Criteria in this chapter.

Drywells are typically a minimum of 48 inches in diameter and approximately 5 to 10 feet deep, or more.

Filter fabric (geotextile) may need to be placed on top of the drain rock and on trench or drywell sides prior to backfilling to prevent migration of fines into the drain rock, depending on local soil conditions and local jurisdiction requirements.

Drywells should be no closer than 30 feet center to center or twice the depth, whichever is greater.

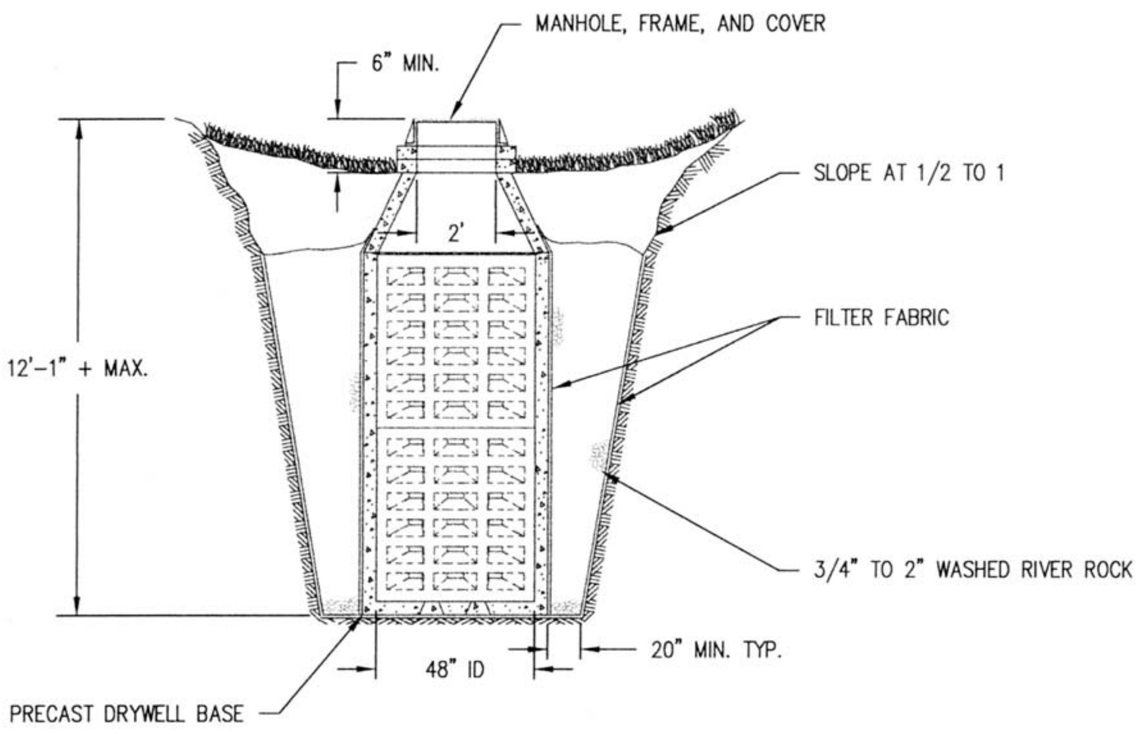
Drywells should not be built on slopes greater than 25% (4:1).

Drywells may not be placed on or above a landslide hazard area or slopes greater than 15% without evaluation by a professional engineer with geotechnical expertise or qualified geologist and jurisdiction approval.

Maintenance Criteria for Drywells

Remove debris and sediment from the drywell grate on a semi-annual basis, or as required to prevent the buildup of materials that could inhibit infiltration.

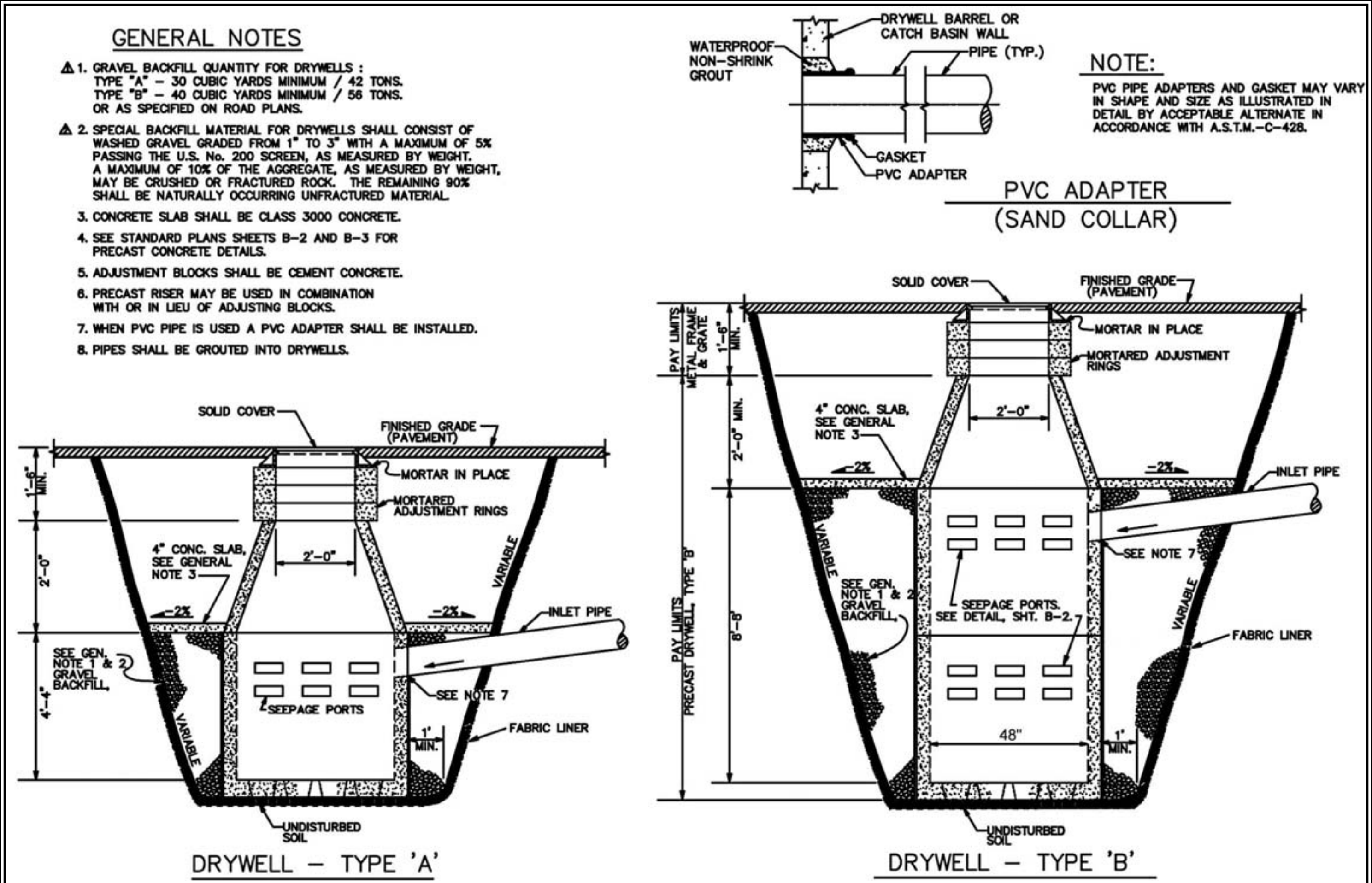
City of East Wenatchee Standard Detail



Source: RH2 Engineering, Inc., Wenatchee

Figure 6.3.1 – Sample infiltration drywell (not to scale)

Spokane County Standard Detail



Source: Spokane County Public Works

Figure 6.3.2 – Sample infiltration drywell

City of Kennewick Standard Detail

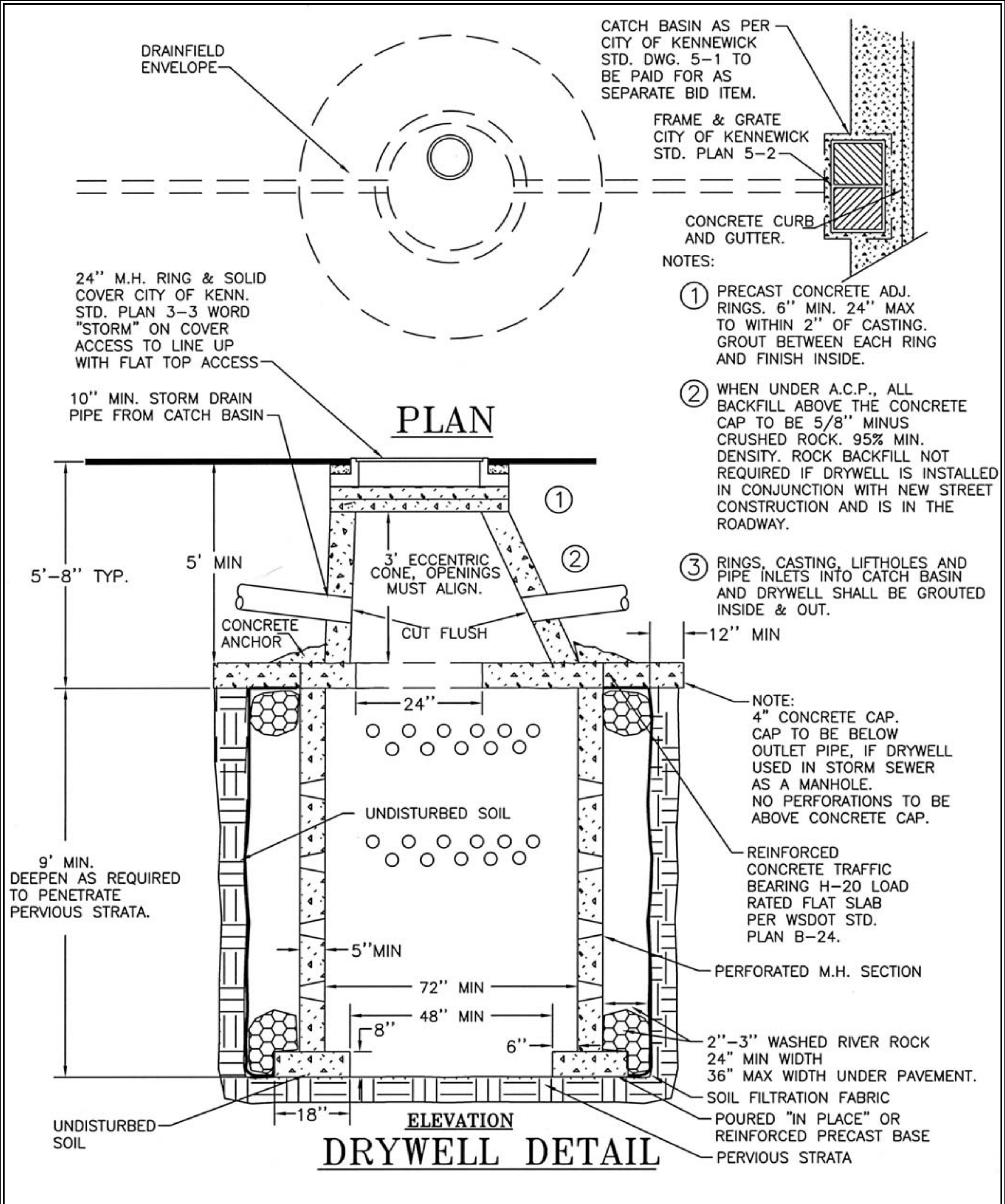


Figure 6.3.3 – Sample infiltration drywell

BMP F6.21 Infiltration Ponds

Description

Infiltration ponds are earthen impoundments used for the collection, temporary storage and infiltration of incoming stormwater runoff. This section covers design and maintenance criteria specific for infiltration ponds (see schematic in Figure 6.3.4). Infiltration ponds are not subject to UIC regulations (see Chapter 5.6).

Design Criteria

See Appendix 6B or Table 5.4.1 for design infiltration rates. Check with the local jurisdiction for outflow capacity requirements.

Access should be provided for vehicles to easily maintain the forebay (pre-settling pond) area and not disturb vegetation, or re-suspend sediment any more than is necessary. See Section 6.2.1 for design criteria regarding access roads.

A minimum of one foot of freeboard is recommended when establishing the design ponded water depth. Freeboard is measured from the rim of the infiltration facility to the maximum ponding level or from the rim down to the overflow point if overflow or a spillway is included.

Lining Material - Ponds can be open or covered with a 6 to 12-inch layer of filter material such as coarse sand, or a suitable filter fabric to help prevent the buildup of impervious deposits on the soil surface. A non-woven geotextile should be selected that will function sufficiently without plugging. The filter layer can be replaced or cleaned when/if it becomes clogged.

Vegetation – The embankment, emergency spillways, spoil and borrow areas, and other disturbed areas should be stabilized and planted, preferably with grass, in accordance with the Stormwater Site Plan (See Chapter 3). Without healthy vegetation the surface soil pores would quickly plug.

Maintenance Criteria

Maintain pond floor and side slopes to minimize erosion. This enhances infiltration, prevents erosion and consequent sedimentation of the pond floor, and prevents invasive weed growth. Where appropriate, bare spots are to be immediately stabilized and re-vegetated.

Vegetation growth should not be allowed to exceed 18 inches in height. Mow the slopes periodically and check for clogging, and erosion.

Seed mixtures should be appropriate for the climate. The use of slow-growing, stoloniferous grasses will permit long intervals between mowing. Mowing twice a year is generally satisfactory for cool season grasses; native warm season grasses should be mowed once every three years to stimulate growth. Fertilizers should be applied only as necessary and in limited amounts to avoid contributing to ground water pollution. Consult the local extension agency for appropriate fertilizer types, including slow release fertilizers, and application rates.

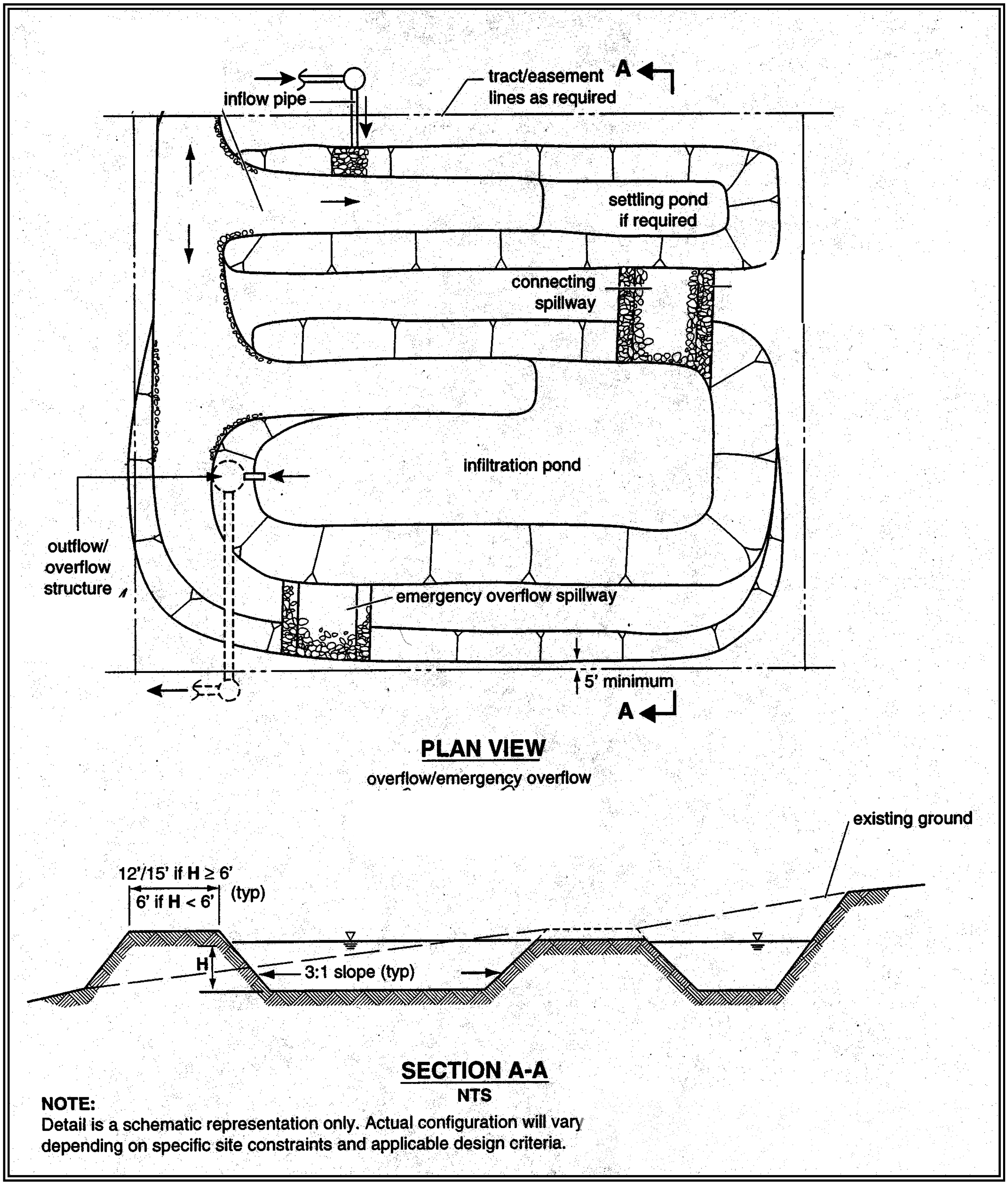


Figure 6.3.4– Typical infiltration pond

BMP F6.22 Infiltration Trenches

This section covers design, construction, and maintenance criteria specific for infiltration trenches. UIC regulations apply only when perforated pipe is installed in the trench; see Chapter 5.6.

Description

Infiltration trenches are generally at least 24 inches wide, and are backfilled with a coarse stone aggregate, allowing for temporary storage of stormwater runoff in the voids of the aggregate material. Stored runoff then gradually infiltrates into the surrounding soil. The surface of the trench can be covered with grating and/or consist of stone, gabion, sand, or a grassed covered area with a surface inlet. Perforated rigid pipe of at least 8-inch diameter can also be used to distribute the stormwater in a stone trench.

Design Criteria

See Figures 6.3.5 - 6.3.8 for examples of trench designs.

See Appendix 6B or Table 5.4.1 for design infiltration rates. Check with the local jurisdiction for outflow capacity requirements.

Due to accessibility and maintenance limitations infiltration trenches must be carefully designed and constructed. The local jurisdiction should be contacted for additional specifications.

Consider including an access port or open or grated top for accessibility to conduct inspections and maintenance.

Backfill Material - The aggregate material for the infiltration trench should consist of a clean aggregate with a maximum diameter of 3 inches and a minimum diameter of 1.5 inches. Void space for these aggregates should be in the range of 30 to 40 percent. For calculations assume a void space of 30 percent maximum.

Perforated Pipe - a minimum of 8-inch perforated pipe should be provided to increase the storage capacity of the infiltration trench and to enhance conveyance of flows throughout the trench area.

Geotextile fabric liner - The aggregate fill material shall be completely encased in an engineering geotextile material. In the case of an aggregate surface, geotextile should surround all of the aggregate fill material except for the top one-foot, which is placed over the geotextile. Geotextile fabric with acceptable properties must be carefully selected to avoid plugging.

The bottom sand or geotextile fabric as shown in the attached figures is optional.

Refer to the WSDOT Design Manual, Section 530, pages 1 through 24, where geosynthetics are discussed. This section contains information on functions and applications, types and characteristics, and design approaches. The WSDOT 2002 Standard Specifications, English units version, section 9-33, includes specifications for geotextiles, classed pursuant to the design manual discussions and definitions.

Refer to the Federal Highway Administration Manual “Geosynthetic

Design and Construction Guidelines," Publication No. FHWA HI-95-038, May 1995 for design guidance on geotextiles in drainage applications. Refer to the NCHRP Report 367, "Long-Term Performance of Geosynthetics in Drainage Applications," 1994, for long-term performance data and background on the potential for geotextiles to clog, blind, or to allow piping to occur and how to design for these issues.

Surface Cover - A stone filled trench can be placed under a porous or impervious surface cover to conserve space.

Observation Well - An observation well should be installed at the lower end of the infiltration trench to check water levels, drawdown time, sediment accumulation, and conduct water quality monitoring. Figure 6.3.9 illustrates observation well details. It should consist of a perforated PVC pipe which is 4 to 6 inches in diameter and it should be constructed flush with the ground elevation. For larger trenches a 12-36 inch diameter well can be installed to facilitate maintenance operations such as pumping out the sediment. The top of the well should be capped to discourage vandalism and tampering.

Catch Basin and Tee - A tee section should be provided in the nearest catch basin upstream of the infiltration trench if a catch basin is used. The tee will trap floatable debris and oils.

Construction Criteria

Trench Preparation - Excavated materials must be placed away from the trench sides to enhance trench wall stability. Care should also be taken to keep this material away from slopes, neighboring property, sidewalks and streets. It is recommended that this material be covered with plastic.

Stone Aggregate Placement and Compaction - The stone aggregate should be placed in lifts and compacted using plate compactors. As a rule of thumb, a maximum loose lift thickness of 12 inches is recommended. The compaction process ensures geotextile conformity to the excavation sides, thereby reducing potential piping and geotextile clogging, and settlement problems.

Potential Contamination - Prevent natural or fill soils from intermixing with the stone aggregate. All contaminated stone aggregate must be removed and replaced with uncontaminated stone aggregate.

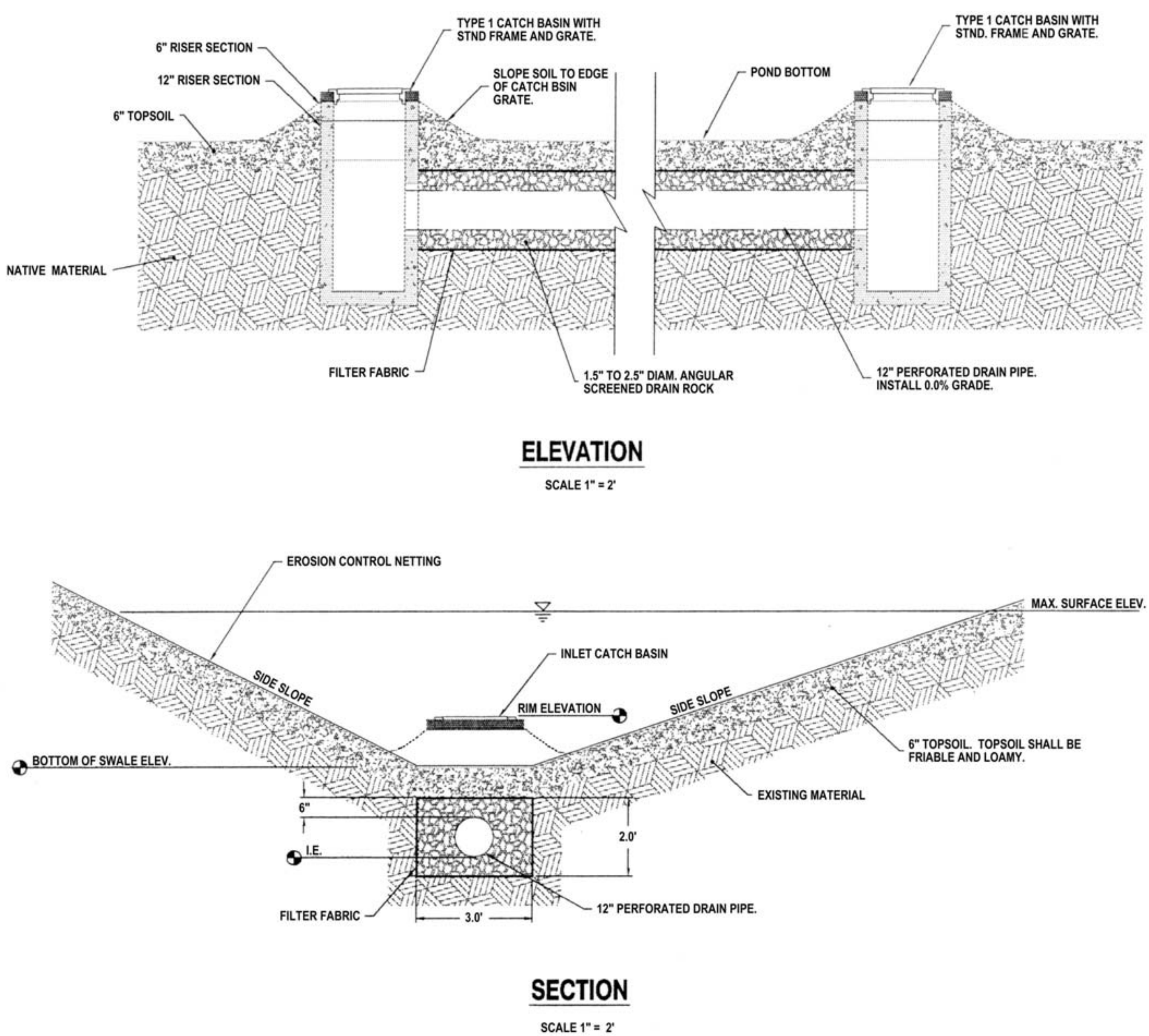
Overlapping and Covering - Following the stone aggregate placement, the geotextile must be folded over the stone aggregate to form a 12 inch minimum longitudinal overlap. When overlaps are required between rolls, the upstream roll should overlap a minimum of 2 feet over the downstream roll in order to provide a shingled effect.

Voids behind Geotextile - Voids between the geotextile and excavation sides must be avoided. Removing boulders or other obstacles from the trench walls is one source of such voids. Natural soils should be placed in these voids at the most convenient time during construction to ensure geotextile conformity to the excavation sides. Soil piping, geotextile clogging, and possible surface subsidence should be avoided by this remedial process.

Unstable Excavation Sites - Vertically excavated walls may be difficult to maintain in areas where the soil moisture is high or where soft or cohesionless soils predominate. Trapezoidal, rather than rectangular, cross-sections may be needed.

Maintenance Criteria

Sediment buildup in the top foot of stone aggregate or the surface inlet should be monitored on the same schedule as the observation well.



Source: RH2 Engineering, Inc., Wenatchee

Figure 6.3.5 – Sample infiltration trench/pond with catch basin inlet

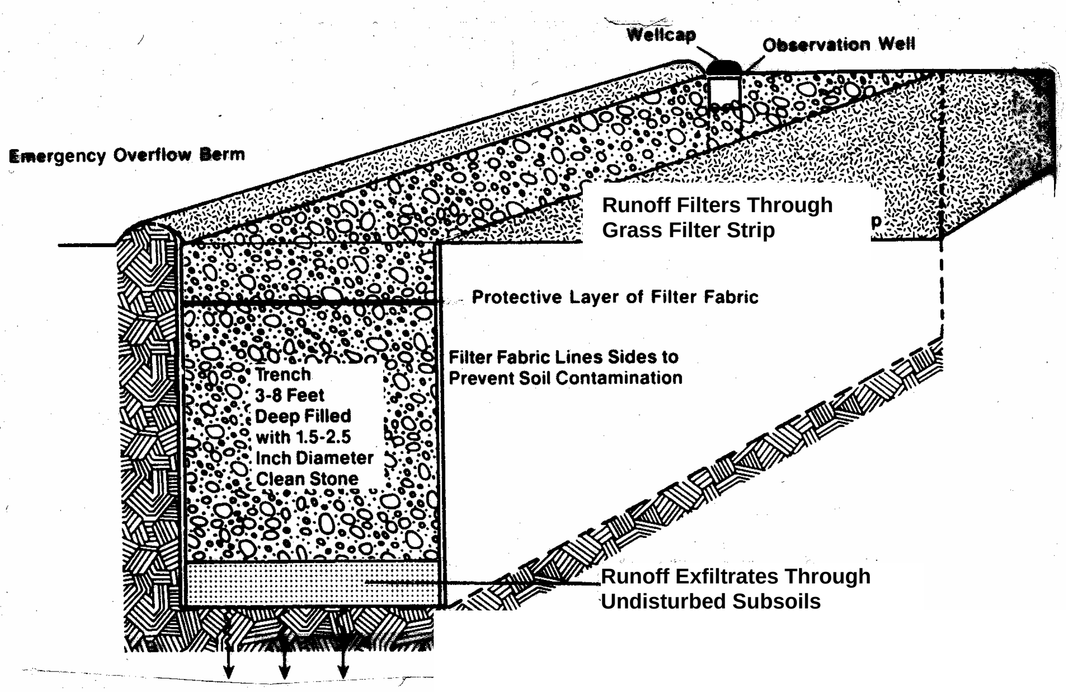
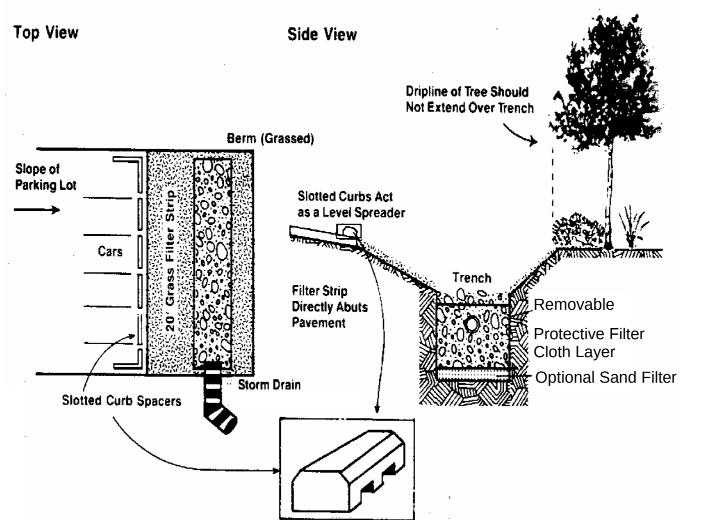
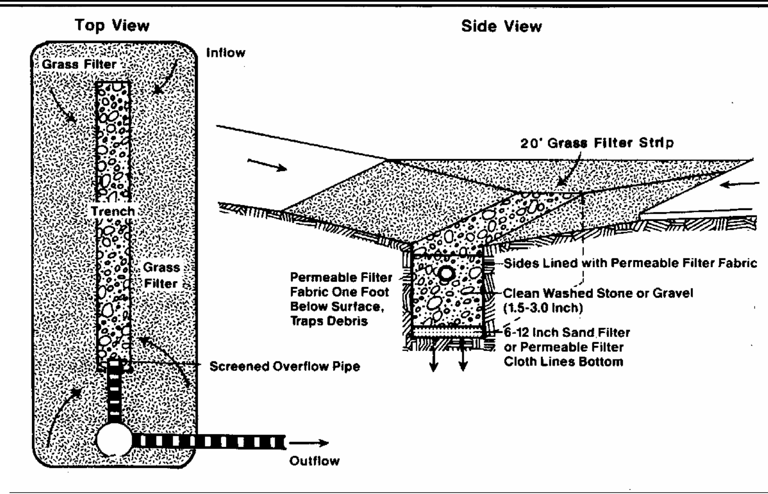


Figure 6.3.6 Schematic of infiltration trench



Source: Schueler (reproduced with permission)

Figure 6.3.7 – Parking lot perimeter trench design



Source: Schueler (reproduced with permission)

Figure 6.3.8 – Median strip trench design

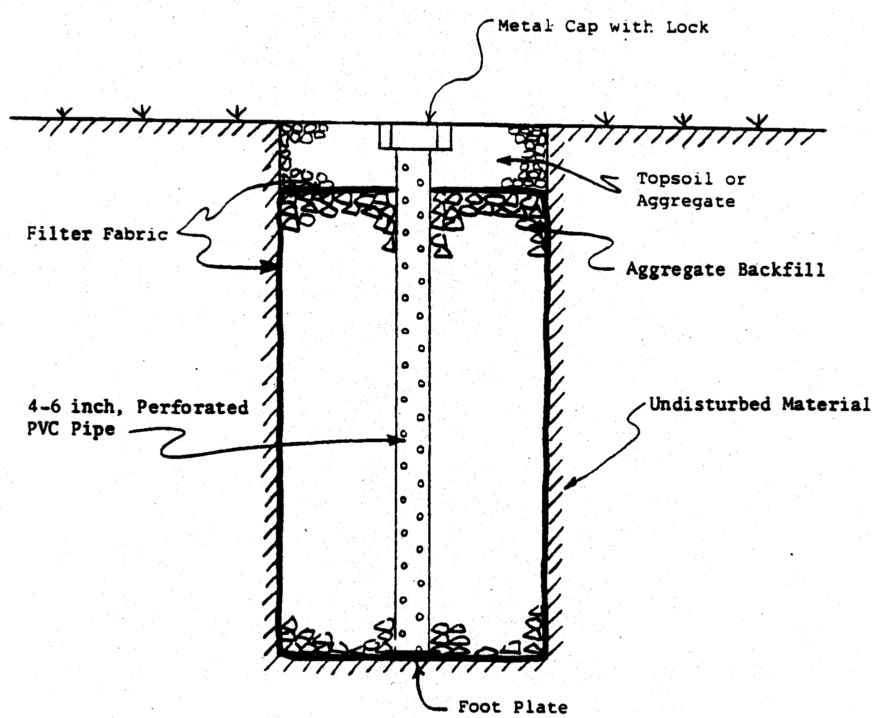


Figure 6.3.9 – Observation well details

6.4 Evaporation Ponds

This section provides the methods for the design of evaporation ponds, which can be used to collect and dispose of stormwater when surface discharge is not available or the soils are not conducive to infiltration facilities.

For the design of evaporative facilities, a water budget is required. A cumulative, month-by-month water budget is performed as follows:

$$V_{in} - V_{out} = \Delta V_{month}$$

$$\Sigma V_{month} = \Delta V_{year}$$

Where:

V_{in} Volume of water into evaporative facility, (usually cubic ft./month). V_{in} is a combination of stormwater runoff, direct rainfall onto the pond surface, groundwater seepage into evaporative facility, and any other source of water into the facility.

V_{out} Volume of water out of the evaporative facility (usually a cubic ft/month). V_{out} is all outflows, it can be a combination surface evaporation, plant evapotranspiration, ground infiltration, or any other qualified outflow.

ΔV_{month} Net volume of storage increase (or decrease) into the evaporative facility (usually cubic ft./month).

ΔV_{year} Cumulative net volume of storage in evaporative facility until storage equilibrium is obtained. Equilibrium is obtained when the volume of water in the cycle is less than the volume stored at the beginning of the cycle, evaluated over at least two calendar years.

It is recommended that a freeboard of at least 1 foot be maintained in the pond at all times. The use of a spreadsheet to perform the calculations can be helpful.

The water budget cycle should be performed on a month-by-month basis, until a steady-state condition occurs (i.e., the volume at the end of the cycle is less than or equal to the volume at the start of the cycle). The minimum duration of the water budget cycle is to be two years. The cycle is to start in the month which yields the greatest net storage volume for the year. Normally, beginning the water budget in September, October, or November produces the largest required storage volume. Contributing off-site areas are to be included in the analysis, considering existing locations.

The climatological data source for evaporation and mean annual precipitation rates used in the water budget are available from the National Oceanic and Atmospheric Administration (NOAA), or other reliable sources. The Western Region Climate Center maintains data for several western states (http://www.wrcc.dri.edu/summary/climsmwa.html). Average monthly precipitation rates and average monthly evaporation rates should be used in the water budget analysis, as a minimum.

UIC regulations do not apply to evaporation ponds (see Chapter 5.6).

6.4.1 Runoff Volume Determinations

Runoff volume from the basin directing stormwater into the evaporative systems shall be included in the water budget analysis. Runoff volume can be determined using the SCS hydrographic method, or other methods approved by the local jurisdiction.

When preparing the water budget, antecedent moisture conditions need to be considered during the months of the year when the ground may be saturated or frozen. For the SCS method the curve numbers (CN) should be adjusted as shown in Table 6.4.1 and Section 4.5. This requirement is applicable in climatic regions 1, 3, and 4 only. Climatic region 2 should use AMC II curve numbers throughout the year.

Table 6.4.1
Curve Number Adjustment for Antecedent Moisture Condition

Month	**Antecedent Moisture Condition (AMC)**	**Minimum Runoff Curve Number (CN)**
April-October	Normal (AMC = II)	See Table 4.5.2
November, March	Wet (AMC = III)	See Table 4.5.3
December-February	-	95

Water loss through evaporation from overland surface areas is normally not to be considered in the water budget, for the areas contributing runoff to the evaporation pond(s), due to the wide variation in evaporation rates which occur over these types of surfaces. The only reduction which can be considered in the analysis is runoff interception and surface infiltration, which are normally accounted for in the SCS curve members or rational coefficients.

Disposal is primarily through evaporation from the pond surface. Credit for infiltration through soils will not be considered in the water budget analysis in the absence of any site specific infiltration testing work being performed.

Geosynthetic or natural liners may be used to limit infiltration outflow volumes in areas where this is desired, or in locations where the seasonal water table will adversely impact the pond.

6.4.2 Other Design Considerations

When credit for infiltration is proposed, site characterization, testing, and reporting must be done in accordance with Section 6.3.

The design of the evaporative facility will need to evaluate the potential of groundwater seeping into the pond from the surrounding area for an unlined pond and evaluate the potential for groundwater mounding or uplift for a lined pond. A geotechnical evaluation should be performed, evaluating this potential negative impact, and, if needed, mitigation measures should be provided.

Sources of imported water need to be considered in the water budget design and calculations. Other sources may include irrigation, sewer septic tank/drainfield systems, natural springs, foundation drains, de-watering wells, etc. The geotechnical engineer shall address this issue in his/her report, and the designer should include any imported water in the water budget analysis.

The maximum water surface elevation permissible in the water budget is to be below the finish floor elevations of the surrounding buildings (existing or proposed). Privately owned parking lot areas, can be used for temporary storage of stormwater and considered in the water budget analysis. If ponding is proposed in parking lot areas, the maximum water depth should normally not exceed 1 foot.

If snow removal operations deposit snow into an evaporative system, this added factor must be considered in the water budget, especially if snow from another basin is put into the system. Temporary sediment ponds should to be included in the design, to prevent sediment-laden runoff from entering the pond and storm disposal system during construction.

6.4.3 Example Calculations

Spokane County's Public Works Department uses a spreadsheet for determining evaporation pond capacity requirements. The design is conservative and at the time of publication of this Manual the calculation process was being evaluated to identify whether changes should be considered.

The spreadsheet is included on the compact disc published with this Manual; it is also available on the Department of Ecology's website. Information on how the spreadsheet is set up and how to use it is provided below. The highlighted fields in the spreadsheet require input or consideration of the designer. An example of the spreadsheet input and results for a sample project site is shown in Table 6.4.2.

For this scenario, the overall drainage basin is 8.00 acres (on-site and off-site, Type B soils, with offsite being uphill and flowing onto the site). The example shown is for full evaporation without discharge via detention to a natural or existing drainage channel.

The example uses data from the nearest station with average monthly precipitation and pan evaporation data available. The monthly precipitation value is adjusted from the first to second column of the spreadsheet based upon the site location. Because evaporation data is collected using a shallow, metal evaporation pan that is fully exposed to sun and wind and affected by heat exchanges within the pan, the pan evaporation rate must be adjusted; the adjustment coefficient should be between 70% and 80%.

The total site area assumes that no off-site property is available for locating the pond; the spreadsheet automatically recalculates the area of the permeable portion of the basin as the pond size goes up or down. The starting point for the pond bottom area is generally to assume 25% of the total site for a typical commercial development.

The pond bottom perimeter is calculated as a square but can be entered manually if the pond perimeter is known. Remember that the perimeter will change if the pond bottom area is increased or decreased during design iterations. As the proposed pond bottom area changes, the portion of the impervious basin area attributed to the pond surface will also change.

The calculations are iterated for two or more years in order to see when the pond has reached a steady state: there should be a decrease the following year in the month with the largest storage (March in the example shown). The calculations assume that the pond contains a dead storage of the equivalent of the 100-year storm because typically, the only time a full-evaporation pond is needed is when there is no discharge point, no infiltrative capacity available, existing high groundwater, or potential for adjacent or downgradient property damage from additional stormwater being injected into the subsurface. The extra capacity provides emergency storage in the event that a site experiences above average total annual precipitation.

Some of the design criteria built into the spreadsheet are specific to Spokane County's Guidelines for Stormwater Management and may need to be adjusted for other local requirements. Among other requirements, Spokane County guidelines state that:

- For impervious surfaces such as roads, sidewalks and driveways, the AMC II CN is 98, and the AMC III CN is 99. From December through February, the assumption is that if the CN of 98 goes up to 99 during the wet months it will not revert to 98 during frozen ground conditions.
- During December through February, the CN for permeable surfaces is 95 regardless of the AMC II or III CNs, meant to approximate runoff from permeable surfaces during snowpack buildup and snowmelt.
- One foot of freeboard is needed above the maximum water surface elevation of the pond.

- **Table 6.4.2 -- Example spreadsheet calculations for sizing an evaporative pond at a site in the Spokane area**

Project :	EXAMPLE SITE IN SPOKANE AREA		
Plat / BSP / Proj No:	###	Engineer:	initials
Date:	8/10/2004		
Pond Bottom Area:		112,000	sq. ft.
Pond Bottom Perimeter:		1,339	ft
Pond Side Slopes:		3	: 1
Impervious Basin Size (Constant):		2.00	acres
Impervious Basin Size (Pond Area):		2.57	acres
Permeable Basin Size:		2.43	acres
Off-Site Upstream Basin:		1.00	acres
Total Basin Size:	8.00	8.00	acres
Mean Annual Prec. - Airport:		16.11	in
Mean Annual Prec. - Site:		19.70	in
Multiplier:		1.22	
100-Year, 24 Hour, Prec.:		2.70	in

Evaporative Pond to Accommodate 100% of Post-Developed Runoff Volume
(no infiltration allowed)

CONDITION: FULL CONTAINMENT

	AMC II Apr-Oct	AMC III Nov&Mar	--- Dec-Feb
Impervious CN:	98	99	99
Permeable CN:	61	78	95
Off-Site CN:	58	76	95
Impervious S:	0.20	0.10	0.10
Permeable S:	6.39	2.82	0.53
Off-Site S:	7.24	3.16	0.53

RESULTS:	
Pond Volume:	246,080 cu ft
Pond Depth:	2.20 ft
Add 1' freeboard:	3.20 ft

						INFLOW				OUTFLOW		STORAGE	POND DATA	
Month	*Precip. (in)*	*Adjusted Precip. (in)*	*Impervious Runoff Depth (in)*	*Permeable Runoff Depth (in)*	*Off-Site Runoff Depth (in)*	*Impervious Runoff Volume (cu ft)*	*Permeable Runoff Volume (cu ft)*	*Off-Site Runoff Volume (cu ft)*	*NET Runoff Volume (cu ft)*	*Pan Evap. (in)*	*Evap. Vol. Out; 72% Adj. (cu ft)*	*Volume Stored in Pond (cu ft)*	*Pond Depth (ft)*	*Pond Capacity (%)*
												20,878	0.19	8
Oct.	1.22	1.49	1.27	0.01	0.00	21,109	61	1	21,171	2.58	17,453	24,595	0.22	10
Nov.	2.02	2.47	2.35	0.77	0.68	39,043	6,777	2,456	48,276	0.92	6,231	66,640	0.59	26
Dec.	2.22	2.71	2.60	2.17	2.17	43,095	19,145	7,882	70,123	0.51	3,500	133,263	1.19	52
Jan.	2.05	2.51	2.39	1.97	1.97	39,651	17,368	7,151	64,169	0.61	4,274	193,157	1.72	76
Feb.	1.57	1.92	1.80	1.41	1.41	29,930	12,402	5,106	47,438	1.11	7,920	232,675	2.08	91
Mar.	**1.38**	**1.69**	**1.57**	**0.32**	**0.26**	**26,086**	**2,821**	**961**	**29,868**	**2.28**	**16,463**	**246,080**	**2.20**	**96**
Apr.	1.11	1.36	1.14	0.00	0.00	18,914	8	0	18,922	4.45	32,260	232,742	2.08	91
May	1.37	1.68	1.45	0.02	0.01	24,111	204	25	24,340	6.69	48,307	208,776	1.86	82
June	1.27	1.55	1.33	0.01	0.00	22,109	100	5	22,214	8.14	58,357	172,633	1.54	67
July	0.50	0.61	0.42	0.00	0.00	6,974	0	0	6,974	10.70	75,878	103,728	0.93	41
Aug.	0.60	0.73	0.54	0.00	0.00	8,881	0	0	8,881	9.42	65,405	47,205	0.42	18
Sept.	0.80	0.98	0.77	0.00	0.00	12,775	0	0	12,775	5.90	40,247	19,733	0.18	8
Oct.	1.22	1.49	1.27	0.01	0.00	21,109	61	1	21,171	2.58	17,447	23,456	0.21	9
Nov.	2.02	2.47	2.35	0.77	0.68	39,043	6,777	2,456	48,276	0.92	6,229	65,503	0.58	26
Dec.	2.22	2.71	2.60	2.17	2.17	43,095	19,145	7,882	70,123	0.51	3,499	132,127	1.18	52
Jan.	2.05	2.51	2.39	1.97	1.97	39,651	17,368	7,151	64,169	0.61	4,273	192,023	1.71	75
Feb.	1.57	1.92	1.80	1.41	1.41	29,930	12,402	5,106	47,438	1.11	7,918	231,543	2.07	91
Mar.	**1.38**	**1.69**	**1.57**	**0.32**	**0.26**	**26,086**	**2,821**	**961**	**29,868**	**2.28**	**16,457**	**244,954**	**2.19**	**96**
Apr.	1.11	1.36	1.14	0.00	0.00	18,914	8	0	18,922	4.45	32,249	231,627	2.07	91
May	1.37	1.68	1.45	0.02	0.01	24,111	204	25	24,340	6.69	48,291	207,677	1.85	81
June	1.27	1.55	1.33	0.01	0.00	22,109	100	5	22,214	8.14	58,338	171,552	1.53	67
July	0.50	0.61	0.42	0.00	0.00	6,974	0	0	6,974	10.70	75,853	102,673	0.92	40
Aug.	0.60	0.73	0.54	0.00	0.00	8,881	0	0	8,881	9.42	65,383	46,171	0.41	18
Sept.	0.80	0.98	0.77	0.00	0.00	12,775	0	0	12,775	5.90	40,234	18,712	0.17	7

6.5 Natural Dispersion

Natural dispersion attempts to minimize the hydrologic changes created by new impervious surfaces by restoring the natural drainage patterns of sheet flow and infiltration. There are three types of natural dispersion. They are:

- BMP F6.40 Concentrated Flow Dispersion
- BMP F6.41 Sheet Flow Dispersion
- BMP F6.42 Full Dispersion

BMP F6.40 Concentrated Flow Dispersion

Purpose and Definition

Dispersion of concentrated flows from driveways or other pavement through a vegetated pervious area attenuates peak flows by slowing entry of the runoff into the conveyance system, allows for some infiltration, and provides some water quality benefits. Flow dispersion is not subject to UIC regulations (see Chapter 5.6).

Applications and Limitations

- Any situation where concentrated flow can be dispersed through vegetation.
- Dispersion for driveways will generally only be effective for single-family residences on large lots and in rural short plats. Lots proposed by short plats in urban areas will generally be too small to provide effective dispersion of driveway runoff.
- Figure 6.5.1 shows two possible ways of spreading flows from steep driveways.

Design Guidelines

- A vegetated flowpath of at least 50 feet should be maintained between the discharge point and any property line, structure, steep slope, stream, lake, wetland, lake, or other impervious surface.
- A maximum of 700 square feet of impervious area may drain to each dispersion BMP.
- A pad of crushed rock (2 feet wide by 3 feet long by 6 inches deep) shall be placed at each discharge point.
- No erosion or flooding of downstream properties may result.
- Runoff discharged towards landslide hazard areas must be evaluated by a geotechnical engineer or qualified geologist. The discharge point shall not be placed on or above slopes greater than 6:1 or above erosion hazard areas without evaluation by a geotechnical engineer or qualified geologist and approval by the local jurisdiction.
- For sites with septic systems, the discharge point should be downgradient of the drainfield primary and reserve areas. This requirement may be waived by the local jurisdiction if site topography clearly prohibits flows from intersecting the drainfield.

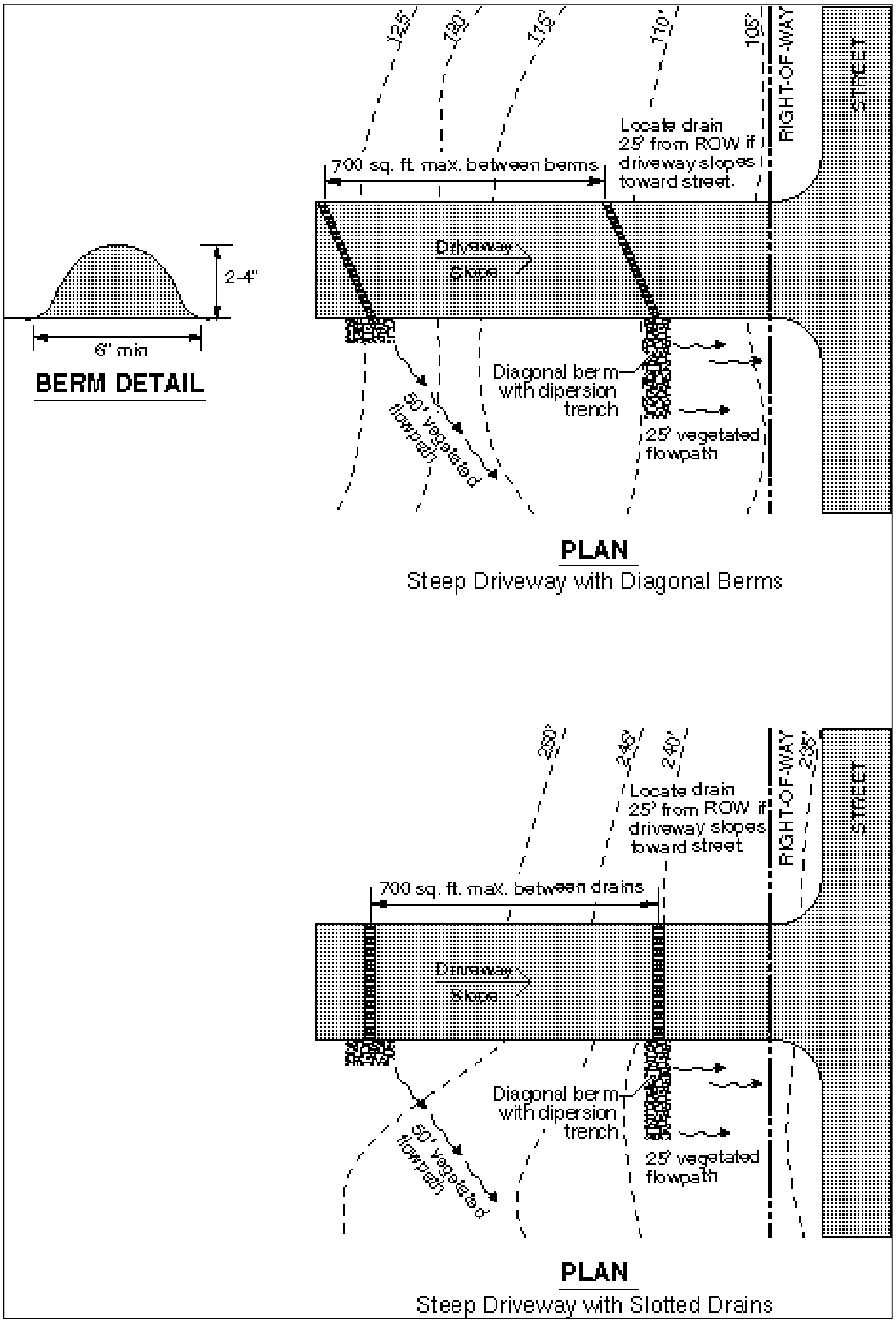


Figure 6.5.1 – Typical concentrated flow dispersion for steep driveways

BMP F6.41 Sheet Flow Dispersion

Purpose and Definition

Sheet flow dispersion is the simplest method of runoff control. This BMP can be used for any impervious or pervious surface that is graded so as to avoid concentrating flows. Because flows are already dispersed as they leave the surface, they need only traverse a narrow band of adjacent vegetation for effective attenuation and treatment. Sheet flow dispersion is not subject to UIC regulations (see Chapter 5.6).

Applications and Limitations

Flat or moderately sloping (<15% slope) impervious surfaces such as driveways, sport courts, patios, and roofs without gutters; sloping cleared areas that are comprised of bare soil, non-native landscaping, lawn, and/or pasture; or any situation where concentration of flows can be avoided.

Design Guidelines

- See Figure 6.5.2 for details for driveways.
- A 2-foot-wide transition zone to discourage channeling should be provided between the edge of the driveway pavement and the downslope vegetation, or under building eaves. This may be an extension of sub-grade material (crushed rock), modular pavement, drain rock, or other material acceptable to the local jurisdiction.
- A vegetated buffer width of 10 feet of vegetation must be provided for up to 20 feet of width of paved or impervious surface. An additional 5 feet of width must be added for each additional 20 feet of width or fraction thereof.
- A vegetated buffer width of 25 feet of vegetation must be provided for up to 150 feet of contributing cleared area (i.e., bare soil, non-native landscaping, lawn, and/or pasture).
- Slopes within the 10- or 25-foot minimum flow path through vegetation should be no steeper than 8 percent. If this criterion cannot be met due to site constraints, the 10- or 25-foot flow path length must be increased 1.5 feet for each percent increase in slope above 8%.
- No erosion or flooding of downstream properties may result.
- Runoff discharge toward landslide hazard areas must be evaluated by a geotechnical engineer or a qualified geologist. The discharge point may not be placed on or above slopes greater than 20% or above erosion hazard areas without evaluation by a geotechnical engineer or qualified geologist and approval by the local jurisdiction.
- For sites with septic systems, the discharge point must be downgradient of the drain field primary and reserve areas. This requirement may be waived by the local jurisdiction if site topography clearly prohibits flows from intersecting the drain field.

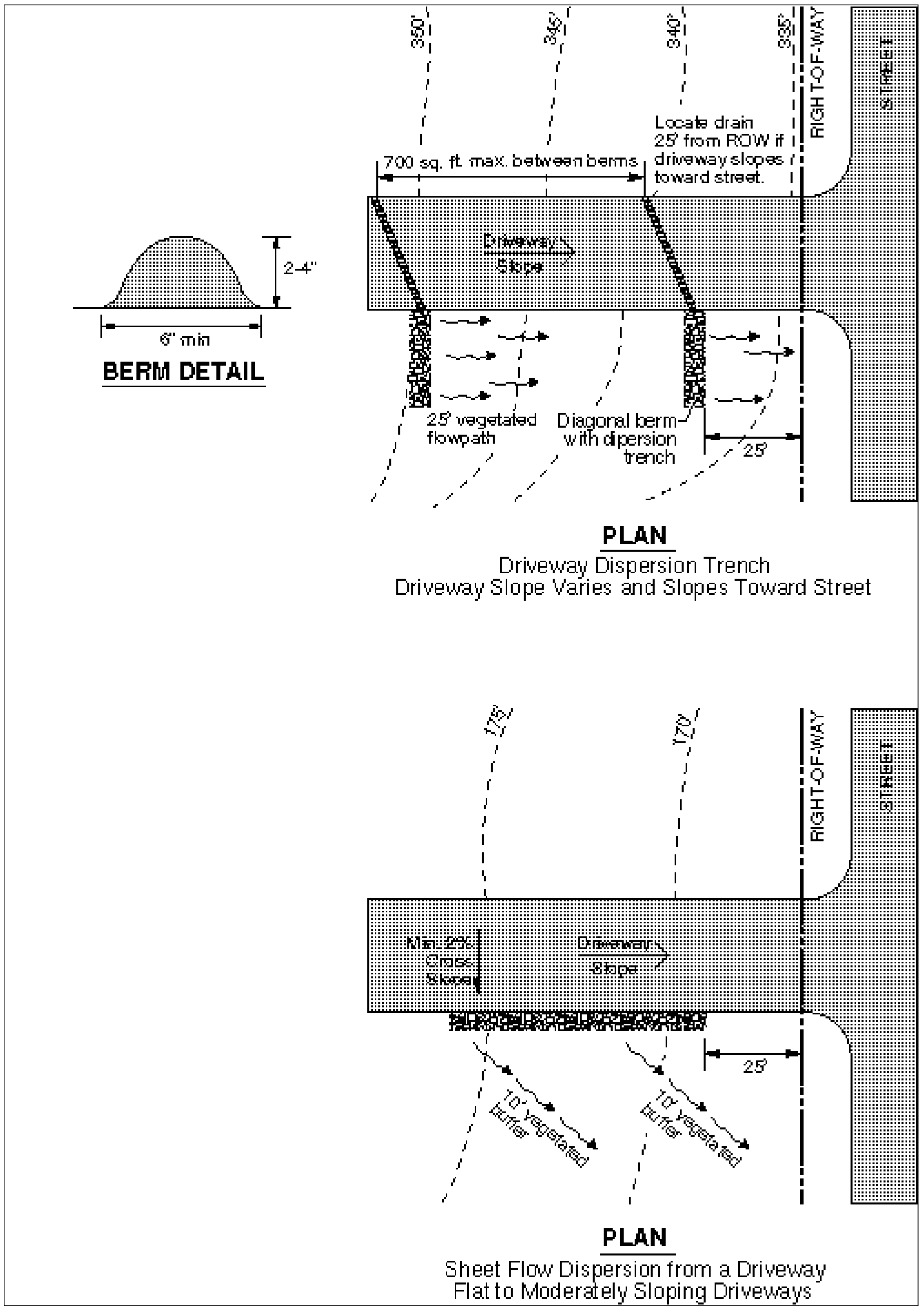


Figure 6.5.2 – Sheet flow dispersion for driveways

BMP F6.42 Full Dispersion

Purpose and Definition
This BMP allows for "fully dispersing" runoff from impervious surfaces and cleared areas of commercial and residential development sites that protect a portion of the site (or for large sites, a portion of an area within a sub-basin drainage on the site) in a natural, native vegetation cover condition. Natural vegetation is preserved and maintained in accordance with guidelines. Runoff from roofs, driveways, and roads within the development is dispersed within the site by utilizing the areas of preserved vegetation.

This BMP is primarily intended for areas of new development. A sliding scale for the amount of preserved vegetated area is provided to allow application to other sites. A dispersion BMP for road projects may be developed and included in the next revised version of the WSDOT *Highway Runoff Manual*.

Full dispersion is not subject to UIC regulations. However, Figure 6.5.3 shows a standard dispersion trench which is subject to UIC regulations; see Chapter 5.6.

Applications and Limitations

- Up to 10% of the site that is impervious surface can be rendered non-effective impervious area by dispersing runoff from it into the native vegetation area. Any additional impervious areas (this BMP recommends limiting additional impervious areas to not more than another 10% for rural areas) are considered effective impervious surfaces with the exception of roofs served by drywells.
- Types of development that retain a percentage of the site (or for large sites, a portion of an area within a sub-basin drainage on the site) in a natural forested or other native vegetation cover condition may also use these BMPs to avoid triggering the flow control facility requirement or to minimize its use at the site.

Design Guidelines
Impervious areas of residential developments can meet treatment and flow control requirements by distributing runoff into native vegetation areas that meet the limitations and design guidelines below if the ratio of impervious area to native vegetation area does not exceed 15%. Vegetation must be preserved and maintained according to the following requirements:

- The preserved area should be situated to minimize the clearing of existing natural vegetative cover, to maximize the preservation of wetlands, and to buffer stream corridors.
- The preserved area should be placed in a separate tract or protected through recorded easements for individual lots.

- If feasible, the preserved area should be located downslope from the building sites, since flow control and water quality are enhanced by flow dispersion through undisturbed soils and native vegetation.
- The preserved area should be shown on all property maps and should be clearly marked during clearing and construction on the site.
- Vegetation and trees should not be removed from the natural growth retention area, except for the removal of dangerous and diseased trees.

The requirement operates on a "sliding scale" comparing the percentage of the site with undisturbed native vegetation to the percentage of the site with impervious surface that drains into those areas of preserved native vegetation:

% of site with impervious surface that drains into native vegetation area	% of site with undisturbed native vegetation
10.0	65
9.0	60
8.25	55
7.5	50
6.75	45
6.0	40
5.25	35
4.5	30
3.75	25
3.0	20

Roof Downspouts: Roof surfaces that are connected to drywells are considered "fully dispersed" provided that they are designed according to local requirements. Otherwise, the roof runoff is assumed to run into the street, and that volume must be added to the volume dispersed in the roadway dispersion component of this BMP.

Driveway Dispersion: Driveway surfaces are considered to be "fully dispersed" if the site meets the required ratio of impervious surfaces to preserved native vegetation above, and if they comply with the driveway dispersion BMPs – BMP T6.40 and BMP T6.41 - and have flow paths through native vegetation exceeding 100 feet. This also holds true for any driveway surfaces that comply with the roadway dispersion BMPs described below.

Roadway Dispersion BMPs: Roadway surfaces are considered to be "fully dispersed" if the site meets the required ratio of impervious surfaces to preserved native vegetation above, and if they comply with the following dispersion requirements:

- Roadway runoff dispersion is allowed only on rural neighborhood collectors and local access streets. To the extent feasible, driveways should be dispersed to the same standards as roadways to ensure adequate water quality protection of downstream resources.

- The road section shall be designed to minimize collection and concentration of roadway runoff. Sheet flow over roadway fill slopes (i.e., where roadway subgrade is above adjacent right-of-way) should be used wherever possible to avoid concentration.
- When it is necessary to collect and concentrate runoff from the roadway and adjacent upstream areas (e.g., in a ditch on a cut slope), concentrated flows shall be incrementally discharged from the ditch via cross culverts or at the ends of cut sections. These incremental discharges of newly concentrated flows shall not exceed 0.5 cfs at any one discharge point from a ditch for the 100-year runoff event. Where flows at a particular ditch discharge point were already concentrated under existing site conditions (e.g., in a natural channel that crosses the roadway alignment), the 0.5-cfs limit would be in addition to the existing concentrated peak flows.
- Ditch discharge points with up to 0.2 cfs discharge for the peak 100-year flow shall use rock pads or dispersion trenches to disperse flows. Ditch discharge points with between 0.2 and 0.5 cfs discharge for the 100-year peak flow shall use only dispersion trenches to disperse flows.
- Dispersion trenches shall be designed to accept surface flows (free discharge) from a pipe, culvert, or ditch end, shall be aligned perpendicular to the flowpath, and shall be minimum 2 feet by 2 feet in section, 50 feet in length, filled with ¾-inch to 1½-inch washed rock, and provided with a level notched grade board (see Figure 6.5.3). Manifolds may be used to split flows up to 2 cfs discharge for the 100-year peak flow between up to 4 trenches. Dispersion trenches shall have a minimum spacing of 50 feet.
- After being dispersed with rock pads or trenches, flows from ditch discharge points must traverse a minimum of 100 feet of undisturbed native vegetation before leaving the project site, or entering an existing onsite channel carrying existing concentrated flows across the road alignment.
  Note: In order to provide the 100-foot flowpath length to an existing channel, some roadway runoff may unavoidably enter the channel undispersed. Also note that water quality treatment may be waived for roadway runoff dispersed through 100 feet of undisturbed native vegetation.
- Flowpaths from adjacent discharge points must not intersect within the 100-foot flowpath lengths, and dispersed flow from a discharge point must not be intercepted by another discharge point. To enhance the flow control and water quality effects of dispersion, the flowpath shall not exceed 15% slope, and shall be located within designated open space.
  Note: Runoff may be conveyed to an area meeting these flowpath criteria.
- Ditch discharge points shall be located a minimum of 100 feet upgradient of steep slopes (i.e., slopes steeper than 40%), wetlands, and streams.

- Where the local jurisdiction determines there is a potential for significant adverse impacts downstream (e.g., erosive steep slopes or existing downstream drainage problems), dispersion of roadway runoff may not be allowed, or other measures may be required.

Cleared Area Dispersion BMPs: The runoff from cleared areas that are comprised of bare soil, non-native landscaping, lawn, and/or pasture is considered to be "fully dispersed" if it is dispersed through at least 25 feet of native vegetation in accordance with the following criteria:

- The contributing flowpath of cleared area being dispersed must be no more than 150 feet, and
- Slopes within the 25-foot minimum flowpath through native vegetation should be no steeper than 8%. If this criterion can not be met due to site constraints, the 25-foot flowpath length must be increased 1.5 feet for each percent increase in slope above 8%.

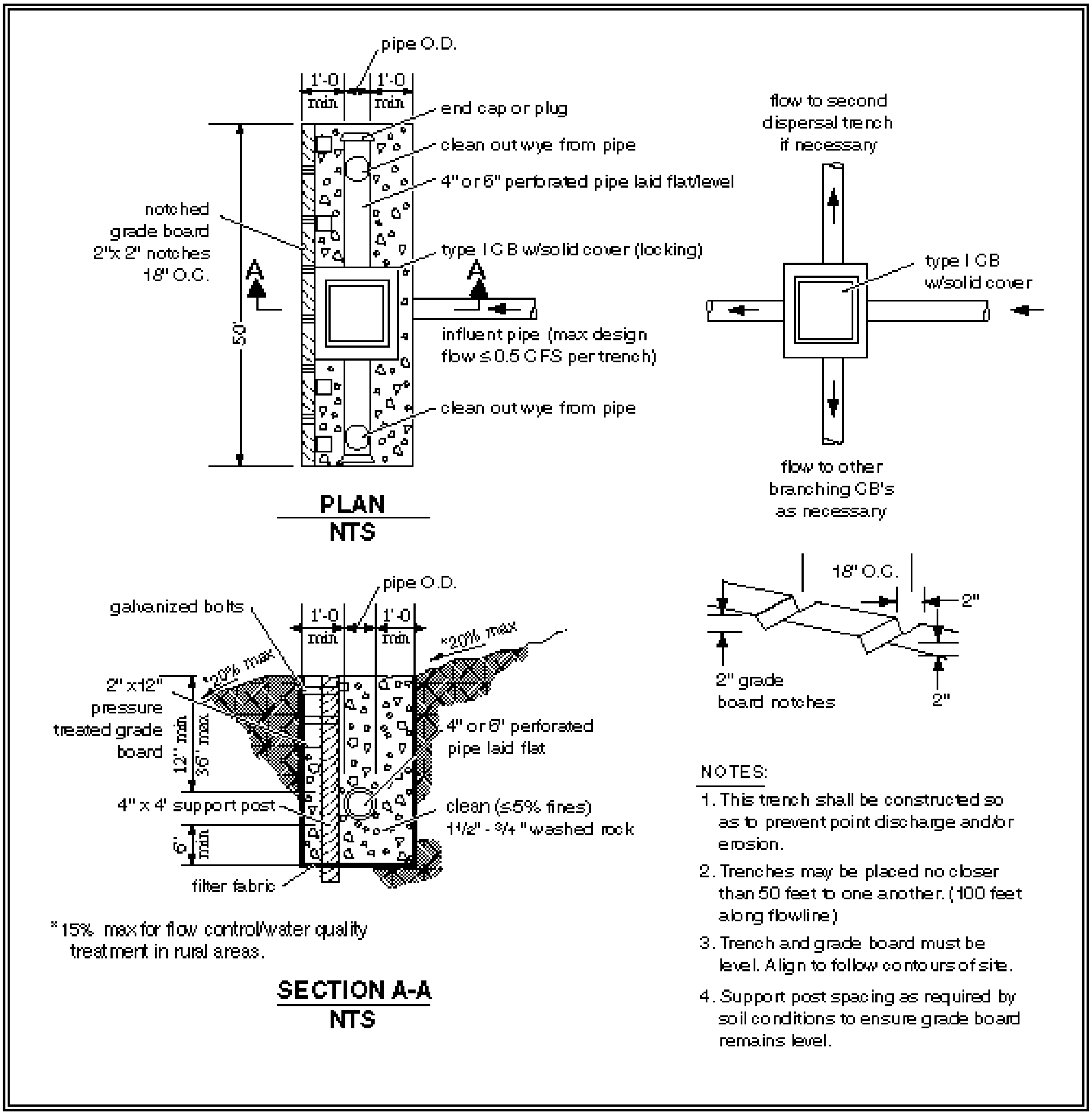


Figure 6.5.3 – Standard dispersion trench with notched grade board

Appendix 6A – Maintenance Requirements

Maintenance Requirements for Detention Ponds

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash & Debris	**Any trash and debris which exceed 5 cubic feet per 1,000 square feet (this is about equal to the amount of trash it would take to fill up one standard size garbage can). In general, there should be no visual evidence of dumping.** If less than threshold all trash and debris will be removed as part of next scheduled maintenance.	Trash and debris cleared from site.
	Poisonous Vegetation and noxious weeds	Any poisonous or nuisance vegetation which may constitute a hazard to maintenance personnel or the public. Any evidence of noxious weeds as defined by State or local regulations. (Apply requirements of adopted Integrated Pest Management (IPM) policies for the use of herbicides).	No danger of poisonous vegetation where maintenance personnel or the public might normally be. (Coordinate with local health department) Complete eradication of noxious weeds may not be possible. Compliance with State or local eradication policies required
	Contaminants and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants (Coordinate removal/cleanup with local water quality response agency).	No contaminants or pollutants present.
	Rodent Holes	Any evidence of rodent holes if facility is acting as a dam or berm, or any evidence of water piping through dam or berm via rodent holes.	Rodents destroyed and dam or berm repaired. (Coordinate with local health department and Ecology Dam Safety Office if pone exceeds 10 acre feet)
	Beaver Dams	Dam results in change or function of the facility.	Facility is returned to design function. (Coordinate trapping of beavers and removal of dams with appropriate permitting agencies)
	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted IPM policies.

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
	Tree Growth and Hazard Trees	Tree growth does not allow maintenance access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements). If trees are not interfering with access or maintenance, do not remove If dead, diseased, or dying trees are identified (Use a certified Arborist to determine health of tree or removal requirements)	Trees do not hinder maintenance activities. Harvested trees should be recycled into mulch or other beneficial uses (e.g., alders for firewood). Remove hazard trees
Side Slopes of Pond	Erosion	Eroded damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion. Any erosion observed on a compacted berm embankment.	Slopes should be stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction. If erosion is occurring on compacted berms a licensed civil engineer should be consulted to resolve source of erosion.
Storage Area	Sediment	Accumulated sediment that exceeds 10% of the designed pond depth unless otherwise specified or affects inletting or outletting condition of the facility.	Sediment cleaned out to designed pond shape and depth; pond reseeded if necessary to control erosion.
	Liner (If Applicable)	Liner is visible and has more than three 1/4-inch holes in it.	Liner repaired or replaced. Liner is fully covered.
Pond Berms (Dikes)	Settlements	Any part of berm which has settled 4 inches lower than the design elevation. If settlement is apparent measure berm to determine amount of settlement. Settling can be an indication of more severe problems with the berm or outlet works. A licensed civil engineer should be consulted to determine the source of the settlement.	Dike is built back to the design elevation.
	Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue. (Recommend a Goethechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.	Piping eliminated. Erosion potential resolved.

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Emergency Overflow/Spill way and Berms over 4 feet in height	Tree Growth	Tree growth on emergency spillways create blockage problems and may cause failure of the berm due to uncontrolled overtopping. Tree growth on berms over 4 feet in height may lead to piping through the berm which could lead to failure of the berm.	Trees should be removed. If root system is small (base less than 4 inches) the root system may be left in place. Otherwise the roots should be removed and the berm restored. A licensed civil engineer should be consulted for proper berm/spillway restoration.
	Piping	Discernible water flow through pond berm. Ongoing erosion with potential for erosion to continue. (Recommend a Goethechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.	Piping eliminated. Erosion potential resolved.
Emergency Overflow/Spill way	Emergency Overflow/ Spillway	Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil at the top of out flow path of spillway. (Rip-rap on inside slopes need not be replaced.)	Rocks and pad depth are restored to design standards.
	Erosion	See “Side slopes of Pond”	

Maintenance Requirements for Detention Vaults/Tanks

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Storage Area	Plugged Air Vents	One-half of the cross section of a vent is blocked at any point or the vent is damaged.	Vents open and functioning.
	Debris and Sediment	Accumulated sediment depth exceeds 10% of the diameter of the storage area for 1/2 length of storage vault or any point depth exceeds 15% of diameter. (Example: 72-inch storage tank would require cleaning when sediment reaches depth of 7 inches for more than 1/2 length of tank.)	All sediment and debris removed from storage area.
	Joints Between Tank/Pipe Section	Any openings or voids allowing material to be transported into facility. (Will require engineering analysis to determine structural stability).	All joint between tank/pipe sections are sealed.
	Tank Pipe Bent Out of Shape	Any part of tank/pipe is bent out of shape more than 10% of its design shape. (Review required by engineer to determine structural stability).	Tank/pipe repaired or replaced to design.
	Vault Structure Includes Cracks in Wall, Bottom, Damage to Frame and/or Top Slab	Cracks wider than 1/2-inch and any evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determines that the vault is not structurally sound.	Vault replaced or repaired to design specifications and is structurally sound.
		Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or any evidence of soil particles entering the vault through the walls.	No cracks more than 1/4-inch wide at the joint of the inlet/outlet pipe.
Manhole	Cover Not in Place	Cover is missing or only partially in place. Any open manhole requires maintenance.	Manhole is closed.
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread (may not apply to self-locking lids).	Mechanism opens with proper tools.

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. Intent is to keep cover from sealing off access to maintenance.	Cover can be removed and reinstalled by one maintenance person.
	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, misalignment, not securely attached to structure wall, rust, or cracks.	Ladder meets design standards. Allows maintenance person safe access.

Maintenance of Control Structures

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and Debris (Includes Sediment)	Material exceeds 25% of sump depth or 1 foot below orifice plate.	Control structure orifice is not blocked. All trash and debris removed.
	Structural Damage	Structure is not securely attached to manhole wall.	Structure securely attached to wall and outlet pipe.
		Structure is not in upright position (allow up to 10% from plumb).	Structure in correct position.
		Connections to outlet pipe are not watertight and show signs of rust.	Connections to outlet pipe are water tight; structure repaired or replaced and works as designed.
		Any holes--other than designed holes--in the structure.	Structure has no holes other than designed holes.
Cleanout Gate	Damaged or Missing	Cleanout gate is not watertight or is missing.	Gate is watertight and works as designed.
		Gate cannot be moved up and down by one maintenance person.	Gate moves up and down easily and is watertight.
		Chain/rod leading to gate is missing or damaged.	Chain is in place and works as designed.
		Gate is rusted over 50% of its surface area.	Gate is repaired or replaced to meet design standards.
Orifice Plate	Damaged or Missing	Control device is not working properly due to missing, out of place, or bent orifice plate.	Plate is in place and works as designed.
	Obstructions	Any trash, debris, sediment, or vegetation blocking the plate.	Plate is free of all obstructions and works as designed.
Overflow Pipe	Obstructions	Any trash or debris blocking (or having the potential of blocking) the overflow pipe.	Pipe is free of all obstructions and works as designed.

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Manhole	See requirements for vaults/tanks		
General	Trash & Debris	Trash or debris which is located immediately in front of the catch basin opening or is blocking inletting capacity of the basin by more than 10%.	No Trash or debris located immediately in front of catch basin or on grate opening.
		Trash or debris (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of six inches clearance from the debris surface to the invert of the lowest pipe.	No trash or debris in the catch basin.
		Trash or debris in any inlet or outlet pipe blocking more than 1/3 of its height.	Inlet and outlet pipes free of trash or debris.
		Dead animals or vegetation that could generate odors that could cause complaints or dangerous gases (e.g., methane).	No dead animals or vegetation present within the catch basin.
	Sediment	Sediment (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of 6 inches clearance from the sediment surface to the invert of the lowest pipe. Measured from the bottom of basin to invert of the lowest pipe into or out of the basin.	No sediment in the catch basin
	Structure Damage to Frame and/or Top Slab	Top slab has holes larger than 2 square inches or cracks wider than 1/4 inch (Intent is to make sure no material is running into basin).	Top slab is free of holes and cracks.
		Frame not sitting flush on top slab, i.e., separation of more than 3/4 inch of the frame from the top slab. Frame not securely attached	Frame is sitting flush on the riser rings or top slab and firmly attached.
	Fractures or Cracks in	Maintenance person judges that structure is unsound.	Basin replaced or repaired to design standards.

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
	Basin Walls/ Bottom	Grout fillet has separated or cracked wider than 1/2 inch and longer than 1 foot at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through cracks.	Pipe is regrouted and secure at basin wall.
	Settlement/ Misalignment	If failure of basin has created a safety, function, or design problem.	Basin replaced or repaired to design standards.
	Vegetation	Vegetation growing across and blocking more than 10% of the basin opening.	No vegetation blocking opening to basin.
		Vegetation growing in inlet/outlet pipe joints that is more than six inches tall and less than six inches apart.	No vegetation or root growth present.
	Contamination and Pollution	See "Detention Ponds"	No pollution present.
Catch Basin Cover	Cover Not in Place	Cover is missing or only partially in place. Any open catch basin requires maintenance.	Catch basin cover is closed
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread.	Mechanism opens with proper tools.
	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. (Intent is keep cover from sealing off access to maintenance.)	Cover can be removed by one maintenance person.
Ladder	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, not securely attached to basin wall, misalignment, rust, cracks, or sharp edges.	Ladder meets design standards and allows maintenance person safe access.
Metal Grates (if applicable)	Grate opening Unsafe	Grate with opening wider than 7/8 inch.	Grate opening meets design standards.
	Trash and Debris	Trash and debris that is blocking more than 20% of grate surface inletting capacity.	Grate free of trash and debris.
	Damaged or Missing.	Grate missing or broken member(s) of the grate.	Grate is in place and meets design standards.

Maintenance Requirements for Drywells

The structural life of a drywell is approximately 20 years, although hydraulic failure could potentially occur at anytime. Drywell performance is dependent upon proper installation, regularly scheduled maintenance and contaminants reaching swale and drywell facility. The following schedule is recommended as a guide; actual schedule may need to be varied based upon observed performance.

Maintenance interval	***Description of maintenance to be performed***
every 3 months	Visually inspect.
every 6 months	Remove debris and sediment.
annually	Check for structural damage.
Whichever is more frequent: above schedule or below observed events:	
following substantial (>24 hr) rainfall event	If possible, observe facilities in operation during the rainfall event. Aim to identify and correct problem prior to failure.
following intense but short duration event	
following snowmelt event	It is especially important to observe the facilities if the melt occurred concurrently with frozen ground conditions.

<u>DEFINITIONS OF MAINTENANCE TASKS</u>:

1) **Visual Inspection**: Ensure metal grate and drywell are free of debris and obstructions. Remove any debris from on top of or around drywell and grate. Remove grate and inspect drywell for debris and sediment build-up in the barrel. Debris needs to be removed immediately, if possible. Sediment needs to be cleaned out before depth reaches the lowest row of slots providing outflow from drywell barrel.

   Anytime that standing water is noticed in a drywell or swale more than 24 hours after an event has ceased, a visual inspection is warranted. When standing water is observed, the inspector should be aware of any signs of illicit discharge. If any of the following are observed, in addition to the sod and topsoil being affected and requiring replacement, if it is evident that discharge was made directly into the drywell, the drywell and affected surrounding drain rock must be replaced as soon as possible: oil sheen, spilled paint, burned area due to battery acid, multi-colored appearance of antifreeze, brown to black fuel oil, or any other materials that may be deemed deleterious to water quality. Sod, topsoil and drain rock removed must be handled and disposed of in a manner consistent with a hazardous material.

2) **Remove Debris and Sediment:** Remove any large debris that would interfere with the vactoring (suction removal) of the drywell. Sediment must be completely suctioned out of the drywell barrel. Care should be taken to note the depth of the sediment. If it appears that the sediment is increasing with depth at each inspection, this may be a sign that the swale is not functioning properly; stormwater may be ponding and spilling, carrying sediment laden stormwater into the drywell, rather than infiltrating at the design rate.

3) **Check for Structural Damage:** Inspect metal frame and grate, adjustment rings, mortar or any other visible parts of the drywell structure. The metal frame and grate should sit flush on the top ring. Any separation of ¾ inch of greater must be adjusted and repaired. The drywell should be replaced or repaired to design standards if it has settled more than 2 inches or if standing water fails to drain out of the barrel slots. Adjustment rings should be free of cracks. Crack repair should adhere be performed when:

location of crack	***maximum width of crack***
top ring of drywell	¼ inch
drywell barrel	½ inch and longer than 3 feet
drywell floor	½ inch and longer than 1 foot

   It should be noted that any crack, regardless of location or width, in which sediment is observed, needs to be repaired as soon as possible. Cracks should be repaired with mortar similar to that used between the adjustment rings. Mortar or grout should be waterproof and of the non-shrink variety.

Maintenance Requirements for Infiltration Ponds

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash & Debris	See "Detention Ponds".	See "Detention Ponds".
	Poisonous/Noxious Vegetation	See "Detention Ponds".	See "Detention Ponds".
	Contaminants and Pollution	See "Detention Ponds".	See "Detention Ponds".
	Rodent Holes	See "Detention Ponds".	See "Detention Ponds".
Storage Area	Sediment	Water ponding in infiltration pond after rainfall ceases and appropriate time allowed for infiltration. (A percolation test pit or test of facility indicates facility is only working at 90% of its designed capabilities. If two inches or more sediment is present, remove).	Sediment is removed and/or facility is cleaned so that infiltration system works according to design.
Filter Bags (if applicable)	Filled with Sediment and Debris	Sediment and debris fill bag more than 1/2 full.	Filter bag is replaced or system is redesigned.
Rock Filters	Sediment and Debris	By visual inspection, little or no water flows through filter during heavy rain storms.	Gravel in rock filter is replaced.
Side Slopes of Pond	Erosion	See "Detention Ponds".	See "Detention Ponds".
Emergency Overflow Spillway and Berms over 4 feet in height.	Tree Growth	See "Detention Ponds".	See "Detention Ponds".
	Piping	See "Detention Ponds".	See "Detention Ponds".
Emergency Overflow Spillway	Rock Missing	See "Detention Ponds".	See "Detention Ponds".
	Erosion	See "Detention Ponds".	See "Detention Ponds".
Pre-settling Ponds and Vaults	Facility or sump filled with Sediment and/or debris	6" or designed sediment trap depth of sediment.	Sediment is removed.

Maintenance Requirements for Evaporation Ponds

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash & Debris	See "Detention Ponds".	See "Detention Ponds".
	Poisonous/Noxious Vegetation	See "Detention Ponds".	See "Detention Ponds".
	Contaminants and Pollution	See "Detention Ponds".	See "Detention Ponds".
	Rodent Holes	See "Detention Ponds".	See "Detention Ponds".
Side Slopes of Pond	Erosion	See "Detention Ponds".	See "Detention Ponds".
Storage Area	Sediment	Accumulated sediment that exceeds 10% of the designed pond depth unless otherwise specified or affects inletting or outletting condition of the facility.	Sediment cleaned out to designed pond shape and depth; pond reseeded if necessary to control erosion.
	Liner (If Applicable)	Liner is visible and has more than three 1/4-inch holes in it.	Liner repaired or replaced. Liner is fully covered.
Pond Berms (Dikes)	Settlements	Any part of berm which has settled 4 inches lower than the design elevation. If settlement is apparent, measure berm to determine amount of settlement. Settling can be an indication of more severe problems with the berm or outlet works. A licensed civil engineer should be consulted to determine the source of the settlement.	Dike is built back to the design elevation.
	Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue. (Recommend a Goethechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.	Piping eliminated. Erosion potential resolved.
General	Inlet Pipe	Inlet pipe clogged with sediment and/or debris material.	No clogging or blockage in the inlet and outlet piping.
	Oil Sheen on Water	Prevalent and visible oil sheen.	Oil removed from water using oil-absorbent pads or vactor truck. Source of oil located and corrected. If chronic low levels of oil persist, plant wetland plants such as Juncus effusus (soft rush) which can uptake small concentrations of oil.
	Erosion	Erosion of the pond's side slopes and/or scouring of the pond bottom, that exceeds 6-inches, or where continued erosion is prevalent.	Slopes stabilized using proper erosion control measures and repair methods.
	Overflow Spillway	Rock is missing and soil is exposed at top of spillway or outside slope.	Rocks replaced to specifications.

Maintenance Requirements for Evaporation Ponds

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General (cont'd)	Snow	Snow removal operations deposit snow into evaporative system	This added factor must be considered in the water budget, especially if snow from another basin is put into the system. Temporary sediment ponds should be included in the design, to prevent sediment-laden runoff from entering the pond and storm disposal system during construction.

Appendix 6B – Storm Drainage Design Guideline for Site Characterization

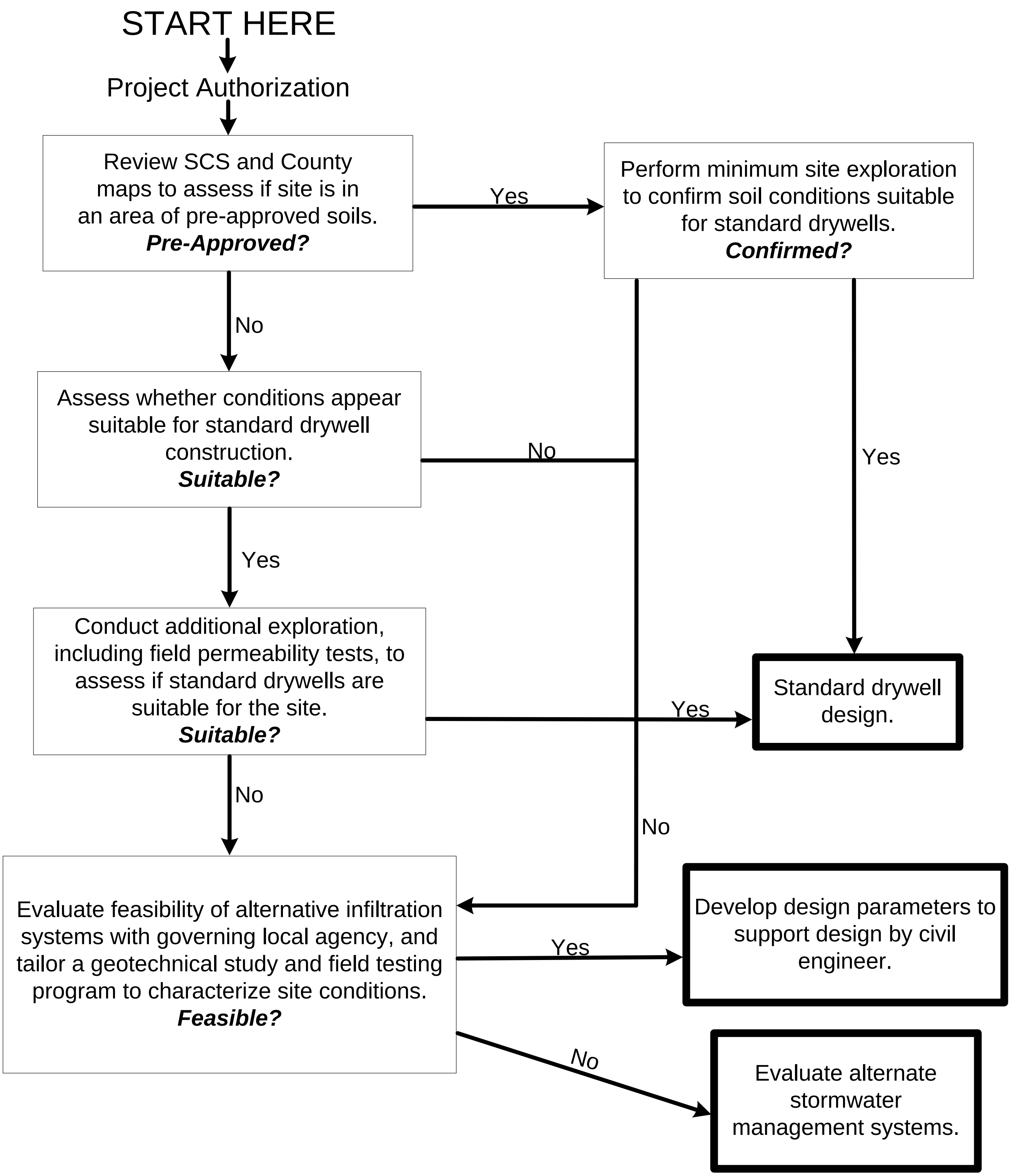
6B.1 Storm Drainage Design Guideline for Site Characterization

Geotechnical site characterization should be conducted to demonstrate the site's general suitability for on-site storm water disposal. The scope of the investigation should consist of, but not be limited to, the following elements:

1. Review applicable geologic maps of the site area, to identify any site conditions that can impact the use of storm drainage disposal systems. This may include outcrops, borrow pits, or existing ground water conditions.
2. Site explorations should consist of a minimum of three exploratory test pits or borings on the site and specifically in the planned disposal area. The explorations should extend at least 5 feet below the bottom of the proposed disposal facility. Deeper site exploration (10 to 50 feet) may be needed if well logs are not available.
3. Samples recovered from the site exploration work may be tested to assess gradational characteristics to help verify the soil classification for comparison with the mapped soil unit.
4. Include a surface reconnaissance of surrounding properties, particularly in the anticipated down-gradient ground water flow direction, to assess potential impact of additional ground water.
5. Perform laboratory testing to determine Unified Soil Classification Group Symbol and Group Name of the site soils.
6. Provide a summary report, describing the results of the work. Include a vicinity map, an exploration site plan, and laboratory test results. Include information regarding the depth to ground water and the presence of any limiting layers which may control ground water flow. Consider feasibility and limitations for on-site disposal. Include information on how the field permeability testing was performed and the assumptions made for determining the recommended infiltration rate. The report shall be prepared under the direction of a licensed professional civil engineer or geotechnical engineer and appropriately signed and sealed.

Note: The following figure and subsequent sections of this Appendix are taken from Spokane County Public Works' guidance for infiltration facilities. The information was current at the time of publication of this manual but may be updated.

Drywell Site Investigation Flow Chart



6B.2 Required Minimum Permeability for Use with Standard Drywell Practice

Spokane County Standard Type "A" or Type "B" drywells discharging at assumed rates of 0.3 cfs and 1.0 cfs, respectively, are allowed in soil groups other than Springdale, Garrison, Bonner, Hagen, Bong, Phoebe, and Marble provided the other standard drywell practice conditions are met, and the soil surrounding the drywell has a minimum permeability of 2.5 X 10^{-2} cm/s when tested in accordance with the field procedures outlined in this appendix.

Derivation of Minimum Permeability ("k") Value

This minimum required value is based upon modeling the drywell as a reverse well and applying an equation presented in USBR Test Procedure 7300-89 that relates outflow rate from an injection well under constant head conditions to soil permeability and other well geometric properties.

The derivation of this rate is presented on the following page of this appendix.

Please note that permeability "k" is used in the context of Darcy's Equation that describes flow through porous media:

$$Q = k * i * A$$

where: Q = Flow Rate in units of Volume/Time
k = Permeability in units of Length/Time
i = Hydraulic Gradient in units of Length/Length
A = Cross sectional area of flow in units of Length Squared

Also please note the difference between permeability "k" as described above and the soil infiltration rate “I”. Within the context of this appendix, infiltration rate “I”, is used to indicate a volume flow rate moving across a surface boundary having an area "A" (i.e. cfs / square foot).

2.5 X IO^{-2} cm/s Threshold Permeability Criteria Derivation

Basis for 2.5 X IO^{-2} cm/s minimum permeability criteria for standard drywells. Reference: "Performing Field Permeability Testing by the Well Permeameter Method" USBR Procedure 7300-89.

Given: Wetted perimeter of Type B standard drywell with 10-foot bore depth is about 600 square feet, (per Spokane County calculation 'circa 1992).

USBR Equation for Condition I (thickness of unsaturated strata greater than 3H, where H is the height of the water in the drywell).

The design equation is:

$$k = \frac{q}{2\pi H^2}\left(Ln\left[\frac{H}{r} + \sqrt{\left(\frac{H}{r}\right)^2 + 1}\right] - \frac{\sqrt{1+\left(\frac{H}{r}\right)^2}}{H/r} + \frac{1}{H/r} \right)$$

The design equation is solved for the permeability (k) required for a constant inflow (q) of 1 cfs. Geometric parameters required include H and r. A standard Type B drywell installation, with an inverted conical envelope of drainage gravel provides approximately 600SF of side slope infiltration area. An equivalent cylindrical surface, having a side area of 600SF and a 10 ft. depth, would require an effective radius (r) of about 9.5 ft.

Using these parameters, the minimum required k for q = 1 cfs is therefore:
7.8×10^{-4} ft/sec = 2.4×10^{-2} cm/sec

6B.3 Recommended Field Test Procedures

Four standard field test methods are discussed in this section:

- Borehole methods, for determining permeability,
- Test pit methods, for determining permeability,
- Single-ring infiltrometer, for determining soil infiltration rate, and
- Constant head conditions, for determining outflow rate.

Estimating Field Permeability of Soil-in-Place Using Borehole Methods

(February 6, 1996)

Applicability

This test method is applicable for determining permeabilities for use in the design of standard and non-standard systems utilizing drywells. Note: Design deviation is required for all non-standard subsurface disposal systems.

Method

1) Using a hollow-stem. auger, advance a 6-inch-diameter or greater borehole to a depth of 2 to 5 feet below the anticipated elevation of the proposed drainage structure. Use care not to contaminate the sides of the hole with fines.

2) Install a slotted pipe or well-screen into the hole having a minimum diameter of 2 inches and a minimum 20% open area through the hollow-stem portion of the auger-string. Install the pipe as nearly as is practical to the bottom of the hole. Wrapping the pipe with a highly porous, non-woven , geotextile fabric is an allowable practice.

3) During auger removal, install a gravel-pack of uniform, clean, dry, pervious fine gravel around the slotted pipe. Omission of this step is an allowable practice. However, calculations for permeability must be based upon the original diameter of the borehole, therefore omission of the gravel pack is not recommended.

4) Introduce clean water near the bottom of the hole through the slotted pipe using an in-line, commercially available, flow meter. Prior to the test, field check the accuracy of the flow meter using a suitable container of known volume (i.e. 5 gallon bucket, etc).

5) Raise the water level in the hole until a level consistent with the operating head anticipated in the proposed drainage structure is achieved. Based upon the soil permeability, the subsurface soil profile, and the water supply system available, head levels lower than those anticipated in the drainage structure are permitted.

6) Adjust the flow rate as needed to maintain the constant head level in the hole. Minimum required test time is I hour.

7) Monitor and record the flow rate required to maintain the constant-head level at appropriate intervals. In no case shall the interval exceed 10 minutes in length.

8) Continue maintaining the constant head until a stabilized flow rate has been achieved. Consider the flow rate stable when the incremental flow rate required to maintain the head does not vary by more than about 5% between increments. The intent of this section is to achieve a relatively steady-state flow condition between the minimum I hour test time and a maximum test time of 1+1/2 hours. At the discretion of the on-site engineer or engineering technician, the test may be extended beyond the 1+1/2 hour maximum.

9) Upon completion of the constant-head period, discontinue flow, and monitor the head level drop in the borehole at appropriate intervals over at least a 30-minute falling-head period.

10) Compute the permeability for the constant head portion of the test using methods outlined in the following: United States Bureau of Reclamation Procedure 73000-89: Performing Field Permeability Testing By The Well Permeameter Method. And USBR Procedure 7305-89: Field Permeability Test (Shallow-Well Permeameter Method). Note: Utilize stabilized flow rates observed near the end of the constant-head period in the permeability calculations.

11) At a minimum the test report shall include a description of the equipment used to conduct the test (including type of flow meter used and the results of the on-site, flow meter accuracy check); difficulties encountered during drilling and testing, a subsurface log of the soils encountered; depth and diameter of the bore-hole; type of gravel-pack used (including visual description); type of slotted pipe used, raw data for both constant & falling head periods including

flow meter readings, incremental flow rates and observed head levels; and calculations showing how the reported permeability rates were computed.

Estimating Field Permeability of Soil-in-Place Using Test Pit Methods

(February 6, 1996)

Applicability

This test method is applicable for determining permeabilities for use in the design of non-standard, alternative subsurface disposal systems incorporating such features as subsurface trenches, subsurface galleries, low-profile drywells, etc. Note: Design deviation is required for all non-standard subsurface disposal systems.

Method

1) Excavate a rectangular test pit having approximate dimensions of 2 feet in width and 4 feet in length. Extend the pit until its bottom elevation is approximately 2 feet to 5 feet below the bottom elevation of the proposed drainage structure. As much as is practical, excavate the pit to neat-fine dimensions, and keep it free of surface slough, organics, and other deleterious material.
2) Line the walls and bottom of the pit with a highly porous, non-woven, geotextile fabric. Install a vertical, PVC observation pipe in the pit. Then backfill the pit with clean, uniform, pervious, fine gravel; or clean, uniform, pervious, open-graded coarse gravel. Note that omission of the PVC observation pipe and pervious gravel backfill is an allowable practice.
3) Introduce clean water into the test pit using an in-line, commercially available, flow meter. Prior to the test, field check the accuracy of the flow meter using a suitable container of known volume (i.e., 5 gallon bucket, 55 gallon barrel, etc).
4) Raise the water level in the pit until a level consistent with the operating head anticipated in the proposed drainage structure is achieved. Based upon the soil permeability, the subsurface soil profile, and the water supply system available, head levels lower than those anticipated in the drainage structure are permitted.
5) Adjust the flow rate as needed to maintain the constant head level in the pit. Minimum required test time is 2 hours.
6) Monitor and record the flow rate required to maintain the constant-head level at appropriate intervals. In no case shall the interval exceed 15 minutes in length.
7) Continue maintaining the constant head until a stabilized flow rate has been achieved. Consider the flow rate stable when the incremental flow rate

required to maintain the head does not vary by more than about 5% between increments. The intent of this section is to achieve a relatively steady-state flow condition between the minimum 2 hour test time and a maximum test time of 2+1/2 hours. At the discretion of the on-site engineer or engineering technician, the test may be extended beyond the 2+1/2 hour maximum. Yes, it is a 2 hour minimum for the pit method.

8) Upon completion of the constant-head period, discontinue flow, and monitor the head level drop in the borehole at appropriate intervals over at least a 30-minute falling-head period.

9) Compute the permeability for the constant head portion of the test using methods outlined in the following: United States Bureau of Reclamation Procedure 73000-89: Performing Field Permeability Testing By The Well Permeameter Method. And USBR Procedure 7305-89: Field Permeability Test (Shallow-Well Permeameter Method). Note: Utilize stabilized flow rates observed near the end of the constant-head period in the permeability calculations. See section 13.3 of USBR Procedure 7300-89 for test pit method.

10) At a minimum the test report shall include a description of the equipment used to conduct the test (including type of flow meter used and the results of the on-site, flow meter accuracy check); difficulties encountered during excavation and testing; a subsurface soil log of the test pit; test pit dimensions; color photographs or color reproductions showing the excavation and soil types encountered; type of fabric lining and/or gravel backfill used; raw data for both constant & failing head periods including flow meter readings, incremental flow rates and observed head levels; and calculations showing how the reported permeability rates were computed.

Estimating Surface Infiltration Rate and Field Permeability Rate Using Single-Ring Infiltrometer Methods

(February 6, 1996)

Applicability

Test method is applicable for estimating infiltration and permeability rates for surficial soils in conjunction with non-standard, subsurface disposal systems incorporating infiltration ponds. Note: Design deviation is required for all nonstandard subsurface disposal systems.

Method

1) Drive, jack, or hand-advance a short section of steel or PVC pipe having a minimum inside diameter of approximately 12 inches, and a beveled leading edge into the soil surface to a depth of about 8 inches. If after installation the surface of the soil surrounding the wall of the ring shows signs of excessive disturbance such as extensive cracking or heaving, reset the ring at another location using methods that will minimize the disturbance. If the surface of

the soil is only slightly disturbed, tamp the soil surrounding the inside and outside wall of the ring until it is as firm as it was prior to disturbance.

2) Introduce clean water into the ring using an in-line, commercially available, flow meter. Prior to the test, field check the accuracy of the flow meter using a suitable container of known volume (i.e. 5 gallon bucket, etc). Use some form of splash-guard or diffuser apparatus such as a highly porous, non-woven, geotextile fabric or a sheet of thin aluminum plate to prevent erosion of the surface of the soil during filling and testing.

3) Raise the water level in the ring until a head-level of at least 6 inches above the soil surface is achieved.

4) Adjust the flow rate as needed to maintain the constant head level in the ring. Minimum required test time is 2 hours.

5) Monitor and record the flow rate required to maintain the constant-head level at appropriate intervals. In no case shall the interval exceed 10 minutes in length.

6) Continue maintaining the constant head until a stabilized flow rate has been achieved. Consider the flow rate stable when the incremental flow rate required to maintain the head does not vary by more than about 5% between increments. The intent of this section is to achieve a relatively steady-state flow condition between the minimum 2 hour test time and a maximum test time of 2+1/2 hours. At the discretion of the on-site engineer or engineering technician, the test may be extended beyond the 2+1/2 hour maximum.

7) Upon completion of the constant-head period, discontinue flow, and monitor the head level drop in the ring at appropriate intervals over at least a 30-minute falling-head period.

8) Compute the surface infiltration rate using the equation: $I = Q/A$ Where I is the surface infiltration rate, Q is the flow rate required to maintain the constant head, and A is the surface area of the soil inside the infiltrometer ring. Use stabilized flow rates observed near the end of the constant-head period to compute the rate.

9) Compute the permeability rate using the following equation:

$$K = (Q * L) / (A * H)$$

Where Q is the flow rate required to maintain the constant head, L is the length of soil column contained within the ring, A is the area of the ring, and H is the head level measured from the base of the ring to the free water surface. This equation is based upon information presented in the U.S. Bureau of Reclamation Drainage Manual section 3-8: Ring Permeameter Test. Use stabilized flow rates observed near the end of the constant head period to compute the rate.

10) At a minimum the test report shall include a description of the equipment used to conduct the test (including type of flow meter used and the results of the

on-site, flow meter accuracy check); a subsurface log of the soils encountered (if test was conducted in the bottom of a test pit), difficulties encountered during testing; raw data for both constant and falling head periods including flow meter readings, incremental flow rates, and observed head levels; and calculations showing how the infiltration and permeability rates were computed.

Estimating Outflow Rate from a Drywell under Full-Scale, Constant Head Conditions

(February 6, 1996)

Applicability

This test method is applicable for confirmation of design outflow rates for newly installed standard and non-standard drywells.

Method

1) Inspect the drywell and make a thorough report of its condition. At a minimum include information on any silt build-up; if there is any standing water in the drywell; whether it is interconnected to other drywells or catch basins by pipes; the overall depth of the drywell from finished grate elevation to bottom; the distance from finished grate elevation to the invert elevation of any interconnecting pipes; the length of the active barrel section. The active barrel section is defined as the length of ported sections from the bottom of the drywell up to the elevation of the base of the solid cone section. Include additional information as is applicable (i.e. age of the drywell, if it appears to have been heavily impacted by unusual factors such as construction practices, etc).
2) Introduce clean water into the drywell using a calibrated, in-line commercially available flow meter.
3) Raise the water level in the drywell until it reaches the top of the active barrel section and then maintain it at that elevation. In the case of drywells interconnected by pipes, raise the water level to the invert elevation of the connecting pipe, or use an expandable pipe plug to seal the connecting pipe.
4) Adjust the flow rate as needed to maintain the constant head level in the hole. Minimum required test time is I hour. Test time begins after the water level in the drywell has reached the top of the active barrel section, or the invert elevation of any interconnecting pipes.
5) Monitor the flow rate required to maintain the constant head level in the drywell at appropriate intervals. In no case shall the interval exceed 10 minutes in length.
6) Continue maintaining the constant head level in the drywell until a stabilized flow rate has been achieved. Consider the flow rate stable when the incremental flow rate required to maintain the head does not vary by more

than 5% between increments. The intent of this section is to achieve a relatively steady-state flow condition between the minimum I hour test time and a maximum test time of 2 hours. At the discretion of the on-site engineer or engineering technician, the test may be extended beyond the 2 hour maximum.

7) Upon completion of the constant head period, discontinue flow and monitor the head level drop in the drywell at appropriate intervals for a 30 minute falling head period.

8) Report test data in a format which includes time of day, flow meter readings, incremental flow rates, observed head levels and water depths in the drywell, and total flow volumes.

References

U.S. Bureau of Reclamation (USBR) 7300-89: Performing Field Permeability Testing by the Well Permeameter Method

U.S. Bureau of Reclamation (USBR) 7305-89: Field Permeability Test (Shallow-Well Permeameter Method)

U.S. Bureau of Reclamation (USBR): Drainage Manual, Chapter 3 - Field & Laboratory Procedures